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Edited by JOHN A. BENN

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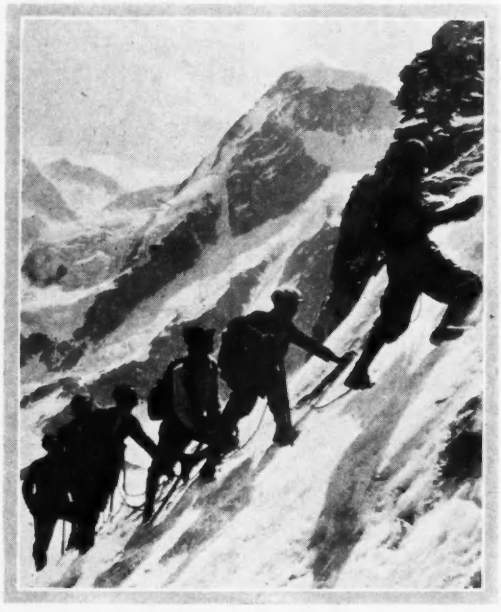

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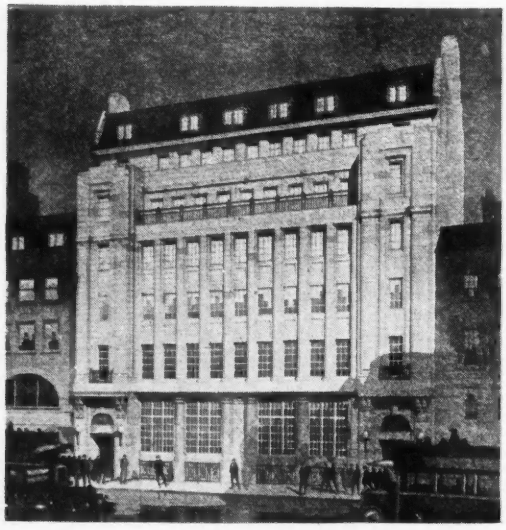

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Editorial Notes.

In beginning with this number our tenth year of publication, it is with particular pleasure that we introduce a new series of articles on the future of the sciences. While *Discovery* does not hesitate to review past history where relevant to the full story of a modern achievement, we endeavour to devote most of our space to new facts and ideas. Writing the opening article on biology, Professor J. Arthur Thomson shows how greatly the outlook has changed since Darwin's day. To an extent not imagined fifty years ago, linkages in the realm of organisms have been discovered, the circle of one creature's life intersecting many other circles. We can now see the far-off results of our interferences, for example, in dealing with parasites and carriers of microbes, and this advance alone is of great importance in practical affairs. Many future aspects of biology are touched upon by our contributor, of which perhaps the most significant concerns the greater recognition of the mental factor. " It is interesting to notice," Professor Thomson concludes, " how some experts in physical science seem at present inclined to extend such concepts as spontaneity into the domain of the inorganic, while many biologists remain in the thraldom of behaviourism. In any case, our increased knowledge of the intelligence and emotions of the highest animals, however we choose to phrase the facts, is bound to lead us back to a view of evolution which would have pleased Darwin."

* * * * *

The second article, in February, will be contributed by Sir John Reith, director of the British Broadcasting Corporation. At the moment when plans have been made public for new and larger headquarters for this giant organization, it is appropriate to ask how precisely the broadcast programmes are to be planned as time goes on, and this question among others will be dealt with under the title " The Next Step in Wireless Broadcasting." Meanwhile, two papers in the present issue call for comment. Professor Gregory, President of the Geological Society, describes the real significance of the eruptions at Etna, which have just caused so much damage in Italy. The volcano has long been the subject of historical interest, and we read that the new eruption was very similar in its form to those of more than two thousand years ago. Another ancient problem is shown in a new light by Sir Arthur Keith, who writes this month on how the racial division of Britain came about. The theory now advanced has been gaining strength for some time, but is by no means generally accepted. A number of difficult problems must be solved before a final verdict can be given.

* * * * *

The future of the coal industry was discussed last month by Lord Melchett, in his presidential address to the Institute of Fuel. In spite of distressing unemployment it is a mistake to suppose that progress is lacking, and methods that are now being developed seem to provide considerable scope for the cure of present troubles. A hopeful factor is the closer attention given to problems of combustion. Lord Melchett said that someone years ago had called coal carbon, but coal was anything but that. The first of the problems depending on the fact that coal was not carbon, but a complicated hydrocarbon, was already being tackled with energy. He was referring to the conversion of coal into oil which would undoubtedly yield an economic solution in the next decade. Further, the problem of the direct employment of coal for what it is, namely, a complicated chemical substance, was as yet in its infancy. On the mechanical side of the fuel industry, the getting of coal in the past has been a craft, but here, as in most other

industries, the man is being partly replaced by the machine. "Our mining engineers are second to none and are subjected to a great amount of totally unfair criticism," Lord Melchett remarked. "The best of our mines are in the first rank." The Fuel Research Board's latest report is reviewed on page 31.

* * * * *

From messages sent by Captain Sir Hubert Wilkins, copyright in *The Times*, we learn that he and his companions have already successfully tested their seaplanes on trial flights from their present base at Deception Island—the first flights ever made in Antarctica. As we write, later, unfavourable weather conditions have unfortunately delayed their start on reconnaissance flights over the presumed coast-line between Graham Land and the Ross Sea. At the same time the American explorer, Commander Byrd, is already on his way to the Antarctic, where he proposes to make a base near the Ross Ice Barrier. Other bases will be established at intervals towards the Pole, and observational inland flights will be made. These expeditions have once more focussed attention on the problems and hazards of exploration on the Antarctic continent. In connexion with past endeavours, it is indeed fortunate that the British Empire Film Institute has been able to buy the cinematographic record of Captain Scott's expedition to the South Pole, to be held in custody for the nation. With improved apparatus and present methods of aerial survey, the new explorers should obtain films of even greater interest.

* * * * *

In the development of aerial survey, Canada has for some years been to the fore. The latest report of achievements during 1928 discloses that 53,000 square miles of territory have been covered by the Government surveyors, working by this method in conjunction with the Canadian Royal Air Force. The operations extended into eight of the nine provinces of the Dominion for such purposes as geological mapping, water-power investigation, and the determination of lumber resources. The oblique aerial photograph fits in well with present needs when maps on the scale of four or more miles to an inch are required. When greater detail and a larger scale in the resulting map sheets are necessary, the vertical method is employed. A striking feature of the season's operations was the taking of aerial photographs of the Lake Seul area, and their use in connexion with a reservoir planned to regulate the flow of waters in the Winnipeg and English rivers, for the development of power. By ordinary methods a survey of the Lake Seul area would have entailed some two or three years' work. However, by the new method the whole area was mapped in a little over three months and the actual construction is already proceeding of an immense storage dam.

* * * * *

Some years ago a proposal was advanced by M. Georges Claude, a distinguished French engineer, for utilizing the thermal energy of the sea Advantage was to be taken of the differences of temperature which exist at various depths in tropical waters. Not unnaturally objections were raised on technical grounds, but it now appears that the method has been tried out in France under practical conditions. According to a description in *Comptes Rendus*, an experiment was made in the River Meuse, using the same methods as will be employed in the final installation of the scheme in Cuba. It was found that only 31 per cent of the output of the power developed was required for the auxiliary operations. Since all the experts thought that such an experiment could not be successful, this result is of exceptional interest.

* * * * *

"Human speech and expression by gesture" was the title given by Sir Richard Paget to a new lecture at the Royal Institution. He developed the theory reported in *Discovery* about a year ago, and gave the results of further research. The idea started with Socrates who supposed that expression by tongue or mouth was an imitation of the thing described, just as deaf-mutes make signs with their hands, head and person generally. This same idea was developed in 1862 by Dr. Rae of Honolulu. Ten years later Charles Darwin noted that there was a natural sympathy of movement between hand and tongue, while Professor Russell Wallace, Darwin's eminent rival, wrote an article in 1895 pointing out that in modern English our tongues commonly make descriptive gestures so as to bring sound and sense into unison. Sir Richard observed that children when they invent words for themselves commonly do so by making, unconsciously, a pantomime with their mouths. In Archaic Chinese, in ancient Sumerian—as spoken at Ur of the Chaldees—in the Aryan and Semitic languages, and even in Polynesia and the west coast of North America, the same root words occur, made by the same descriptive tongue gesture—as, for example, the upward movement of the tongue which produces the word *al* meaning "high" or "strong" or "protect" or "rise." We are told that the reason why the northern races use hand gesture less than the southern is that they lead harder lives and have less hand leisure.

The New Eruption of Etna.

By J. W. Gregory, LL.D., D.Sc., F.R.S.
President of the Geological Society.

The severe outbreak of Etna in November was not actually the most terrible in the history of the volcano, of which the first record dates back more than two thousand years. A description of the new eruption is here given, with the story of the superstitions still surviving among the Italian peasants.

ETNA is the loftiest and largest of European volcanoes, and, so far as is known, has been the longest in action. Its summit, varying in height between about 10,700 and 10,900 feet above sea level, is exceeded among European mountains only in the Alps and a few other mountain chains. Its circular base covers 460 square miles, and is 90 miles in circumference. This vast pile has been built up by eruptions which began long before the historic period, and date from the deposition of the Crags of East Anglia. The eruptions have apparently recurred at frequent though irregular intervals.

The earliest record of a volcanic eruption relates to Etna; its activity was described by Pindar in a Pythian Ode in 475 B.C., and eleven eruptions of Etna had been recorded while Vesuvius lay dormant, and before its powers of catastrophic explosion were revealed by the outbreak that destroyed Pompeii and Herculaneum. Vesuvius has since then had repeated paroxysmal explosive eruptions separated by prolonged periods of rest, of which some have lasted for a century and a half. Meanwhile Etna has continued to build up its massive base by the welling forth of sheets of lava at short intervals. This regularity and persistence of Etna show that it depends upon very deep-seated forces. This fact is illustrated by the unusual uniformity in composition of its lavas, which are all basalts of much the same type.

Exceptional Structure.

The special nature of the volcanic activity of Etna depends upon its structure. The mountain consists of a broad, gently sloping, massive base, from which, at the height of about 6,000 feet, rises the steeper central cone. The abrupt passage from the basal mound to the upper cone explains the characteristic feature of Etna—the number and size of its secondary craters. Most large volcanoes have secondary or parasitic cones upon their flanks, and small craters occur on lava streams around the blow-holes of the escaping steam. On Etna these secondary craters are exceptionally large and numerous; they number over two hundred and some of them, if they occurred separately, would be regarded as important volcanoes. These parasitic cones occur mainly around the base of the central cone in a zone wherein the major eruptions of the mountains now happen. The formation of the craters in that position appears due to the reduced strength of the walls of the central pipe of the volcano when it passes from the base into the upper cone. The main pipe in the lower part of the mountain is enclosed by walls so thick that they confine the rising column of liquid lava; but the upper cone is weaker as it is more slender in form and consists of looser materials. Hence the upper cone is unable to support a column of lava tall enough to discharge from the high central crater. The weight of the lengthening column, and the increasing resistance to its rise as it cools and becomes less fluid, together crack the walls of the volcanic pipe. Through the fissures thus produced the lava reaches the surface at outlets around the base of the cone.

Sudden Outbursts.

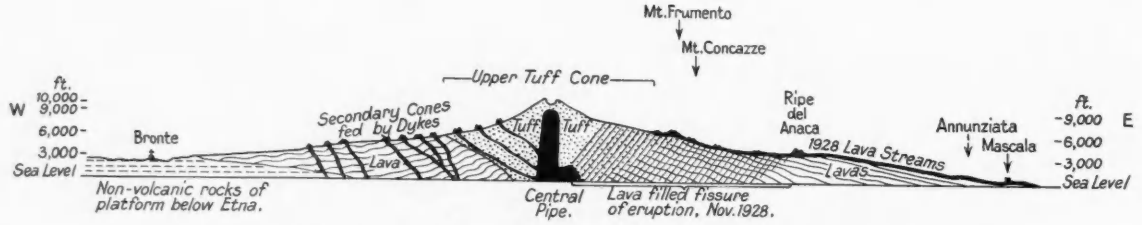
The eruptions often begin suddenly, for the rising lava works its way gradually up the growing fissure, which spreads slowly to the surface as cracks in glass creep slowly outward from the point where a pane has been broken by a blow. When the fissure opens at the surface the relief of pressure enables the water enclosed in the molten rock to burst into steam; its expansion forces the lava upward until the surplus is discharged. If the lava escapes through a long fissure, or along a series of adjacent vents, it wells forth quietly and solidifies in the wide sheets characteristic of Etna. When the lava is discharged through a small aperture it is blown by the explosive escape of the steam into fragments which are piled up as a tuff cone around the vent.

The Etna eruptions are therefore not accompanied by world-shaking explosions, such as that which in 1883 blew Krakatoa into fragments and scattered its material world-wide as impalpable dust. The eruptions are usually preceded by slight local earthquakes as the fissures are formed and extend to the surface. In the early stages of an eruption there may

*

be some explosive discharge; but the main process is the relatively gentle outflow of molten rock. The Etna eruptions therefore usually cause but slight loss of life. Fatal accidents are mostly due to disregard of warnings or to running undue risks through indolence or bravado or in the effort to save property. Occasional disasters have happened through some unusual circumstances. Thus in 1843 a lava flow crossed a swamp; the heat converted the underlying water into steam, which raised the lava above it into a dome, until the colossal bubble burst and killed sixty-nine people. A serious loss of life was narrowly escaped in the last eruption, as a lava stream suddenly changed its course during the night and approached a village silently and swiftly. One man happened to notice its advance and fired his gun to arouse the sleeping villagers, who escaped just in time. The damage to property is, however, often heavy, for the lava tends to flood the most valuable land. The volcanic rocks of Etna decompose into a soil so rich in plant foods, and of such excellent texture, that the land is of extraordinary fertility.

The zone of the mountain up to 3,000 feet has a population of 930 to the square mile, while in an area above Catania the population is reported as 3,056 to the square mile. Etna has one of the densest agricultural populations in the world, and is surpassed only under such conditions as those of the alluvial plains of China and Japan. The fertile areas of Etna are on the ancient decomposed rock in the hollows between the newer lava streams. Each flow naturally runs along the low ground occupied by the villages and orchards. The basal dome of Etna has been built up by the lavas constantly filling up the depressions between the earlier flows. The process is analogous to that by which a river builds up a great alluvial plain by altering its course when it has raised its bed above the level of the adjacent ground; and it repeats this process till its deposits are spread evenly over the floor of the valley. The decay of the rock is so slow that it is not until a century after an eruption that its lava will support a little moss and scanty herbage, and it is estimated that about three hundred years are required for the formation of sufficient soil for cultivation. Hence, though an eruption ultimately enriches the area by bringing from below a new supply of plant foods which refertilize the ground, the land covered by a flow is ruined for centuries.



DIAGRAMMATIC SECTION THROUGH MOUNT ETNA. SCALE ONE INCH = FOUR MILES.

The older non-volcanic rocks of the platform below Etna form the plateau around Bronte; the base of the mountain consists of gently sloping lava flows and the central cone consists of volcanic tuff. The fissure formed during the recent eruption is shown by steeply inclined lines through the tuff and lavas east of the upper cone. The dark line from Monte Frumento to the sea shows the course of the lava streams.

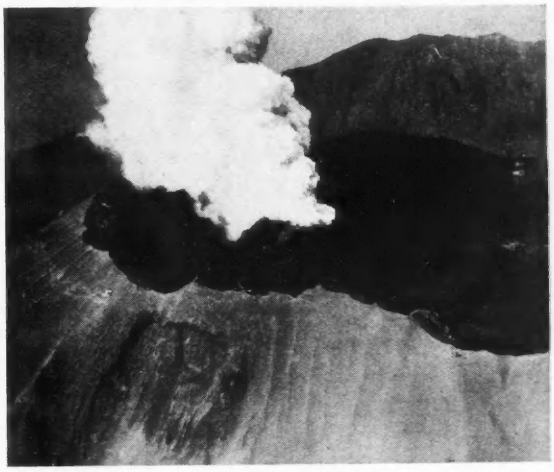
The tragedy of Etna has been the frequent devastation by the lava floods of its most densely peopled and most fertile land. The great eruption of 1669 was discharged from a fissure, twelve miles long and six feet wide, through the southern slope of the mountain. Lava streams from this fissure overflowed fourteen towns and villages, while at two points along it, where the eruption was explosive, were built up two cones, the Monti Rossi. As this lava approached Catania, it advanced more slowly; for, as shown in some of the photographs of the recent eruption, the advance is not by a steady continuous flow as of a sheet of water or mud, but by repeated short jerks. The edge of the lava sheet cools and freezes into a solid crust, which is cracked and broken by the pressure of the molten rock behind. The lava pours through the breaks until its advance is again stopped by the solidification of the surface. Pappalardo, an enterprising citizen of Catania, recognized that the flow could accordingly be to some extent directed in its course. He armed fifty men with long iron poles, and set them, clad in skins as a protection against the heat, to break the crust on one side of the flow. The lava ran out through the gap and away from the direction of the city. He might have saved Catania, had not the inhabitants of Paterno, a town on the south-western slopes of Etna, denounced this intervention with the intentions of Providence, and by force of arms compelled Pappalardo to desist and allow the lava to take its predestined course. The action by the people of Paterno has been attributed to self-defence; but the motive would

appear to have been jealousy of a rival rather than fear for their own safety. For Paterno is twelve miles west of Catania and was far from any of the 1669 lava streams; and it does not appear to have been seriously threatened by any eruption since 745 and 1169. The lava therefore continued its course against Catania, and accumulated against the city wall, which is said to have been 60 feet high. When it reached the top it poured in a molten cascade on to the southern part of the city which it covered on its way to the sea.

The area of Etna increases by encroachment on the surrounding country. The eruption of 1923 again threatened the town of Linguaglossa which stands upon the sandstone just outside the north-eastern border of the volcanic rocks. It had been nearly reached by the lavas of 1566 and of 1865, when Monte Frumento, one of the greater secondary cones, was built up on a fissure in line with six other craters. In 1923 a lava flow three-eighths of a mile wide advanced upon Linguaglossa at the rate of two miles a day; but it was first saved by the lava running down the slope to the east and falling over a cliff, and later during the same year by the lava stream sub-dividing and passing on either side of the town.

The latest eruption of November, 1928, is a good example of the normal type, though it lasted a few days longer than usual. It broke out on the floor of one of the radial valleys of Etna, which forms a triangular depression, about three miles wide, between lava streams to the north that were discharged in 1651, 1776, and 1865, and a southern ridge due to the eruptions of 1254, 1689 and 1865. The floor of the valley is apparently composed of prehistoric lava.

TYPICAL LAVA DAMAGE IN A VILLAGE STREET.



MOUNT ETNA IN ERUPTION.

The eruption was obviously due to the rise of a column of molten rock up the central pipe of the volcano high into the upper cone; the weight burst the walls of the pipe, and formed a fissure that reached the surface on the eastern slope. The eruption began on the afternoon of the 2nd November, when a column of steam was seen from Catania, and soon afterwards eruptions broke out at two additional centres. Each began with explosions by which new vents were formed and small craters built around them. A row of vents from the fissure opened down the mountain side from west to east (see diagram). On the night of the 4th, a vent was opened at Ripe del Anaca at the height of 3,400 feet, and it became the main centre of discharge. The enormous stream of lava which issued from it led to the closing of the upper vents, which had done but little damage, as they were in rough uncultivated ground. The lava from Anaca, however, poured directly over vineyards and orchards. Three lava streams, one of which was 650 yards wide and 10 miles long, flowed eastward down the mountain side, and reached the sea near Riposto; the railway was cut at two points and some villages, including Mascala, were completely buried, despite the image of its patron saint, St. Leonard, having been placed across the path of the advancing lava. On 8th November a new crater opened and discharged a stream which flowed at first at the rate of nearly two miles a day. One of the streams threatened Giarre, a town of 20,000 inhabitants. To save it the priests and people marched in procession to the new craters and beside them celebrated a solemn mass. This service was doubtless regarded as effective, for by that time,

the 12th November, the energy of the eruption was mainly spent, and it ended about the 20th.

By the 13th November, when the discharge had practically ceased, the lava had covered about 1,400 acres of orchards of oranges, lemons, chestnuts and hazelnuts, and over 400 acres of vineyards, and had done damage estimated at about £2,000,000. The first descriptions of the eruption were in some respects exaggerated, for they described it as unprecedented in violence, and in the volume of lava ejected. The eruption was far less powerful than many of its predecessors. According to a telegram to *The Times* (15th November), Professor Ponte stated that the eruption was one of the feeblest—he probably meant gentlest—on record, although it had done an unusual amount of damage. Professor Ponte's remark doubtless refers to the absence of explosions accompanying the eruption. It discharged far less lava than those of 1865 and of 1892, which is said to have lasted six months, or of the lava stream 24 miles long and two miles wide, which, according to Diodorus Siculus, in 396 B.C. protected part of Sicily by stopping the advance of a Carthaginian army.

Supernatural Aid.

The survival of appeals for supernatural aid against the lava is not surprising, when the despairing villagers watch it slowly and irresistibly creep forward, and quietly push over houses and destroy and bury everything in its path. Buckle in his "History of Civilization" illustrated the psychological effect of unavoidable and, to the victims, inexplicable catastrophies, by pointing out that superstition is most rife in Europe in earthquake-stricken districts. In 1923 it was claimed that the advance of the lava against Linguaglossa was stayed by placing in its way the pastoral staff of the patron saint, St. Giles. This step was regarded as so effective that the people of a neighbouring village attacked those in charge of the staff lest it should divert the lava on to their land. The fight was stopped by the Carabinieri, and the relic allowed to remain on the assurance that St. Giles was so benevolent that the influence of his staff would protect both villages.

The question naturally arises whether the eruptions of Etna are connected with those of Vesuvius, and with the terrible earthquakes that have from time to time overthrown Messina and devastated Calabria. The three phenomena are probably all due to the same general cause, which is, however, so deep-seated that its effects on the surface are not closely associated. Vesuvius and Etna are rarely active at the same time. The discharge at one volcano apparently relieves the underground stress at the other. Etna is apparently still less directly connected with the local earthquakes; they do not affect the volcanic area, but the older rocks in north-eastern Sicily and the south-western peninsula of Italy. The last great earthquake at Messina had no observable effect on Etna. Both the earthquakes and volcanoes of Sicily and southern Italy must be due to a disturbance in the deeper levels of the earth's crust; and its great depth is indicated by the independence of the effects at the surface, as well as by the prolonged uniformity in the volcanic activity of Etna. Pindar's description in 475 B.C. would be equally descriptive of a modern eruption—"even snow-clad Etna, who nursest her keen frost for the live-long year—Etna, from whose inmost caves burst forth the purest founts of unapproachable fire, and in the day-time, her rivers roll a lurid stream of smoke, while amid the gloom of night, the ruddy flame, as it sweepeth along, with crashing din whirleth rocks to the deep sea far below. And that monster flingeth aloft the most fearful founts of fire, a wondrous marvel to behold, a wonder even to hear, when men are hard by . . that mount, that forefront of a fruitful land" (Pythian Odes, I, lines 40-60; translated by Sir J. E. Sandys). This account of the molten glowing floods emerging from the cavernous side of the mountain and pouring down its slopes and sometimes reaching the sea shows that the eruptions more than 2,400 years ago were like those of the present day.

Mull and Skye.

Etna has a special interest to British geologists owing to its similarity in activity to the great volcanoes which built up the mountains of Mull and Skye in the Hebrides. Mull, as was pointed out by Judd, must have been built up by a volcano like Etna. It must have been about the same height, and its area was also about 90 miles in circumference. Mull was built up by eruptions in the geological period preceding the first of those of Etna, and it has been so worn down and dissected by the erosion of valleys that the roots of the old volcano are clearly exposed. Mull and Skye have been mapped in detail by the Geological Survey of Scotland, and this work has fully confirmed Judd's view that the mountains of each island include the central core of a great volcano surrounded by radial lava flows of basalt. The base of the mountain is traversed by sheets of intrusive rock, some of which no doubt fed secondary volcanic vents, and some of the intrusive sheets expand upward like an inverted cone. These "cone-sheets," like the secondary cones of Etna, were probably due to the molten rock being blocked in its ascent through the volcanic pipe.

The Next Step.—I.

What is Ahead in Biology ?

By J. Arthur Thomson, M.A., LL.D.

Professor of Natural History in the University of Aberdeen.

Discoveries in biology have now reached a point where theory and fact may be more precisely linked than hitherto. The next steps projected in this article—the first of our new series on various subjects—include the determination of sex ; the relation between heredity and environment ; and the growing recognition of the mental aspect of living creatures.

BIOLOGY has made great progress since Darwin's day. Thus one of the central ideas of Darwinism, the inter-relations of living creatures in the web of life, has found perhaps fifty striking instances for one that was known to Darwin. The heather flourishes because it has a partner fungus ; the clover taps the atmospheric nitrogen because it has bacteria in its root-tubercles ; the larval death-watch, boring in the wainscot, thrives on its dry-as-dust food because it has symbiotic yeasts in its food-canal, and similarly the wood-eating white-ants have their partner infusorians. To an extent not imagined fifty years ago there are linkages in the realm of organisms, the circle of one creature's life intersecting many other circles. This correlation of organisms has come to be recognized as of great practical importance to man, for it has enabled him to see the far-off consequences of his interferences and to deal more effectively with parasitic and microbic diseases that are disseminated by insects and other carriers.

Chemical Messengers.

Descending from the correlation of organisms to the correlation of organs—a question of individual physiology, it is well known how much the outlook has been changed by the discovery of the regulating rôle of the hormones. These chemical messengers are secreted from the ductless glands into the blood and are transported throughout the body, achieving what may be called an orchestration of the various functions. This explains, so far, such mysteries as the activation of the stag's antler-growth or the mother's milk-glands at the appropriate time, or such commonplace occurrences as the indignant cat's hair standing on end before the obtrusive dog. Here also there is a loud sounding of the practical note, since it is now possible, for instance, for the physician to do something to check the tragic disaster, previously a mystery, that is due to a thyroid deficiency in the hopeful baby or the promising adolescent. A knowledge of these endocrinal glands has changed the whole face of physiology and medicine.

How much it would have delighted Darwin to know, as he might have known, of the work of Mendel, which has changed our outlook on heredity. The idea of " unit-characters " and their factors within the germ-cells has been in the study of heredity like the atomic theory in chemistry. The change is so radical that it must be called a metamorphosis. It also has its far-reaching practical corollaries, for Mendelism enables the breeder and cultivator to combine desirable characters in a sure and rapid way ; and it has also thrown light on some puzzling peculiarities of human inheritance—both normal and abnormal.

Huxley's Prophecy.

There is a good instance of Huxley's extraordinarily keen biological insight in the prophecy he made in 1878 that it would turn out that the organism was like a web, the woof of which was contributed by the mother and the warp by the father—now a well-verified fact. But we fancy that Huxley would have been surprised if he had heard of the discovery, made by Delage and by Loeb, that quite a number of eggs, not normally parthenogenetic, can be launched on the voyage of development without being fertilized by a sperm. This artificial parthenogenesis is easily brought about in animals like sea-urchins and star-fishes, and up to the level of frogs. A normal frog can be successfully reared that has a mother but no father. It seems reasonable to expect that a following of the clue given by artificial parthenogenesis will lead to a better understanding of what essentially happens when a sperm-cell fertilizes an egg-cell in animal or plant. Perhaps light will also be thrown on the cell-stimulation that leads to abnormal growths like tumours or to such finished neoplasms as oak-apples and other galls.

The discovery of glutathione by Sir Frederick Gowland Hopkins in 1921 may be called a milestone

in the rapid advance of biology in the twentieth century. No attempt need be made to explain how this organic substance is composed of two amino-acids (the building-stones of the proteins which are essential constituents of living matter) ; but the most important biological fact is that this glutathione, of wide occurrence in the cells of plants and animals, has an " oxygen-transporting " function reacting with the oxygen externally supplied via the blood and lymph and able to pass it on indirectly to the combustible fuel in the tissues. This helps to explain how the living creature is a " burning bush " without being consumed, since it means that the numerous and rapid energy-yielding reactions in the living tissues take place at a comparatively low temperature. Perhaps Keilin's cytochrome, a widely distributed, practically colourless cell-pigment, which seems to have to do with the control of oxygen within the cell, is another link in the biochemical chain. It matters little what particular instances are taken—the chemical changes involved in the contraction of muscle or in the photosynthesis of the green leaf, the great step in advance that is still being made is the application of the precise methods of chemistry to a deeper understanding of the facts of life.

Colour Problems.

This biochemical analysis is not only clearing up the internal physiology of the organism, it is deepening the old-fashioned natural history or ecology. Illustrations of this may be obtained from the study of organic pigments. The physiologist has for long been interested in fundamental pigments like the chlorophylls and the hæmoglobins (apparently with subtle relationships), and this is not surprising when their essential importance in the life of plants and animals is brought to mind. But there are many other pigments that have not this directly useful rôle, though they are secondarily of value, perhaps of life-saving or life-fostering value, in concealing or advertising the animal or dressing it up in bright attire for courtship. These secondary utilities sometimes do credit to the naturalist's imagination, but many of them are demonstrable, and in such cases it is quite reasonable to suppose that the coloration may have been gradually elaborated in the course of Natural Selection. In a few cases this has been experimentally tested and verified.

So far, so good. Yet the background difficulty has always been to explain how the coloured material is so abundantly forthcoming ; and it is here that the biochemist makes his contribution, for he discovers the chemical nature and the probable origin of the pigments in question. He finds that the flavone pigment in the wings of the marbled-white butterfly comes from a pigment in the cocksfoot grass on which the caterpillar feeds, and also that the green biliverdin of the vertebrate's bile and of some tissues in invertebrates may be regarded as a degradation product of hæmoglobin. Similarly, the dark melanin pigments, so common in dark hair, feathers, and skin, are readily derivable from some of the abundant amino-acids into which the universally present proteins break down. Thus the common ferment tyrosinase may act on the common amino-acid tyrosin, and yield a dark pigment. The ruddy lipochromes, so widely distributed, from the Norway lobster to the wattle of the red grouse, seem to be traceable back to chlorophyll, which may be taken into the animal directly or indirectly along with its food. The general point should be clear, and it means a notable advance. Given a natural supply of certain pigments, whose presence can be readily accounted for in terms of the chemical routine of the body, then their secondary utilization can be better understood. They are there as by-products for the using, so to speak—for the using, if needs be, in the everyday life of the creature, whether as protection, advertisement or decoration.

Passing from ecology to aetiology, other illustrations are to be found of the deepening insight that biochemistry affords. Thus, in thinking of a fine piece of work like Gautier's analysis of the chemical differences between distinct varieties of grapes, or the work of Reichert and Brown on the minute differences in the hæmoglobins of even nearly related mammals, more than a glimpse of a very important and promising idea—the chemical basis of species—can be obtained. As was said of old time : all flesh is not the same flesh, for there is one kind of flesh of men, another flesh of beasts, another of fishes, and another of birds. Every type has its own protein ; there is a chemical accompaniment of individuality. With ability to synthesize this fact with that of psychical individuality, biology will breathe more deeply.

Difference of Sex.

One of the many unsolved problems of biology is the essential difference between male and female, but it is probable that the solution is not very distant and that it will be furnished by the biochemist. Two spores fall from a moss-capsule and each grows into thread or protonema. The two threads are microscopically indistinguishable, yet in some cases the one thread, or part of it, gives rise to a male moss-plant and the other to a female moss-plant. What is the elusive difference ? Two masses of

bread-mould hyphæ are identical as far as the microscope shows, yet one tangle may be male and the other female, as is proved when they react to one another and form a sexual product.

Now it seems not unlikely that the fundamental difference between male and female will be discovered by the prosecution of researches such as those associated chiefly with Manoilov. He has discovered a reaction which enables him to distinguish the blood of a male from that of a female, in cases such as mice, sheep, and pigeons. It can also be applied to extracts of plants with the sexes separate, such as the dicœcious Lychnis, nettle, willow, poplar, and dog's mercury. It must be admitted that a repetition of Manoilov's tests has not always been satisfactory, but there are many corroborations as well as discrepancies; and the point is that if the chemical treatment, or some other like it (like that used by Steele and Zeimst), does actually serve to discriminate between the blood or extracts of male and female organisms, this will probably lead to a disclosure of the chemical reason for the different reaction. This would then afford a clue to the essential metabolic difference between maleness and femaleness, and would perhaps suggest a method of giving germ-cells a bias in one direction or the other. As is well known, there has been recently considerable progress towards the practical control or determination of sex in lower animals.

The Next Half-Century.

The rôle of prophet is hazardous, but in many cases it does not mean more than a recognition of what has already happened. So reference is made to two great steps which will probably mark the biological work of the next half-century. The first of these will imply a re-focussing of interest on the old question: how does the individual organism come to be as it is? No doubt descriptive embryography has had a long history, but experimental or analytic embryology is still a rapidly growing young science. Yet what is to be seen above the horizon is more than "developmental mechanics," more even than "physiological embryology"—though a logical extension of both. It is the attempt to show by what immediately present factors certain changes are brought about in the individual's Becoming. It is what is to be found illustrated in such books as *Animal Biology* by Haldane and Huxley, or Kyle's *Biology of Fishes*. Let a familiar illustration be taken—the fall of the leaf. Everyone knows of the appropriate growth of the "absciss" layer of rather soft cells across the base of the leaf-stalk. A readily ruptured cushion grows across which helps in foisting off the dying or dead leaf; and to its inner side there is formed the corky scar that heals the wound. The histology of these growths is well known and their usefulness leaps to the eye. But the knowledge needed is the sequence of immediately operative factors that lead to the appearance of these useful structures at the appropriate time. No doubt they are "functions" of hereditary nature and environing nurture, but this is no more than a vague formula. In the next generation it will become increasingly concrete.

To mention an instance from the animal kingdom, there was an obvious step of progress when it became clear that the development of the stag's antlers is activated by a testicular hormone, which is carried by the blood to the frontal bone and evokes one of the most rapid and extravagant of animal growths. But physiological histology must deepen; it must elucidate, for instance, the arrangements, beginning so early, which secure the loss of the antlers at the end of the season. This inquiry has far-reaching applications, for it means an endeavour to show how environmental, nutritional, and habitudinal factors condition the detailed investment of the hereditary legacy.

It may lead, for instance, to a disclosure of the modificational nature of many specific characters—characters which would not find expression if the nurtural conditions were different. Even for man's own sake we need to deepen our knowledge of the Biology of Nurture.

Some students of biology who may have followed this sketch with more or less approval up to this point, will probably jib violently at the word psycho-biology. So this is what the future has in store, a return to vital forces and guiding spirits! But what is to be looked forward to is hardly that; it simply means that there will be an increasing recognition of the mental aspect of living organisms.

Body and Mind.

It will be admitted by all that the study of animal behaviour to-day is in a much healthier state than it was two generations ago, when the account given of an animal's ways was very largely dependent on the observer's temperament. If he was generous, and what William James called "tender-minded," he read the man into the beast without hindrance. Every mammal was a Brer Rabbit and the honey-bee a mathematical genius. But if he was intellectually parsimonious and given to using William of Occam's razor, "tough-minded" as James would say, then he set his face sternly against what he called anthropomorphism and forthwith reduced the animal

to the level of an automatic machine. In shunning the Scylla of anthropomorphism the observer fell into the Charybdis of apsychic behaviourism, or *vice versa*. But the situation has changed for the better; anecdotalism has given way before precise science; and, except on the part of extremists, there is a general recognition of the two complementary aspects clearly discernible in the higher animals, the physiological and the psychological, the metabolism and the mentality, the objective and the subjective.

Even when dealing with expression of hereditarily enregistered capacities—reflexes, tropisms, instincts, and the like—inquiry has to be made into their historical origin, which is almost unthinkable except on the view that the organism is always both *mind*-BODY and *body*-MIND, though sometimes more of the one, sometimes more of the other. It has its hormones but also its hopes, its motions but also it memories, its chemistry and physics, but also its inner life of feeling and desire, imaging and occasionally intelligence. And if it is allowed that a collie-dog is a *body*-MIND as well as a *mind*-BODY, it is difficult to draw any line, either taxonomic or developmental, below which the reality of an inner life of feeling at least would be denied.

Personally I doubt whether it is hopeful to try to describe the origin of a large mutation in a dog's germ-cells without keeping close to the fact that each of these is an implicit organism, by hypothesis with a psychical as well as with a protoplasmic aspect. It is interesting to notice how some experts in physical science seem at present inclined to extend such concepts as spontaneity into the domain of the inorganic, while many biologists remain in the thraldom of behaviourism. In any case, our increased knowledge of the intelligence and emotions of the highest animals, however we choose to phrase the facts, is bound to lead us back to a view of evolution which would have pleased Darwin, an envisaging of a struggle in which organisms are insurgent participants, trading with time and trafficking with circumstance, agents that seek after well-being and share in their own advance. Organic evolution is a long-drawn-out game in which each living creature plays its own hand of hereditary cards. The living creature proves itself not only a colloidal witch's cauldron but a sub-personality.

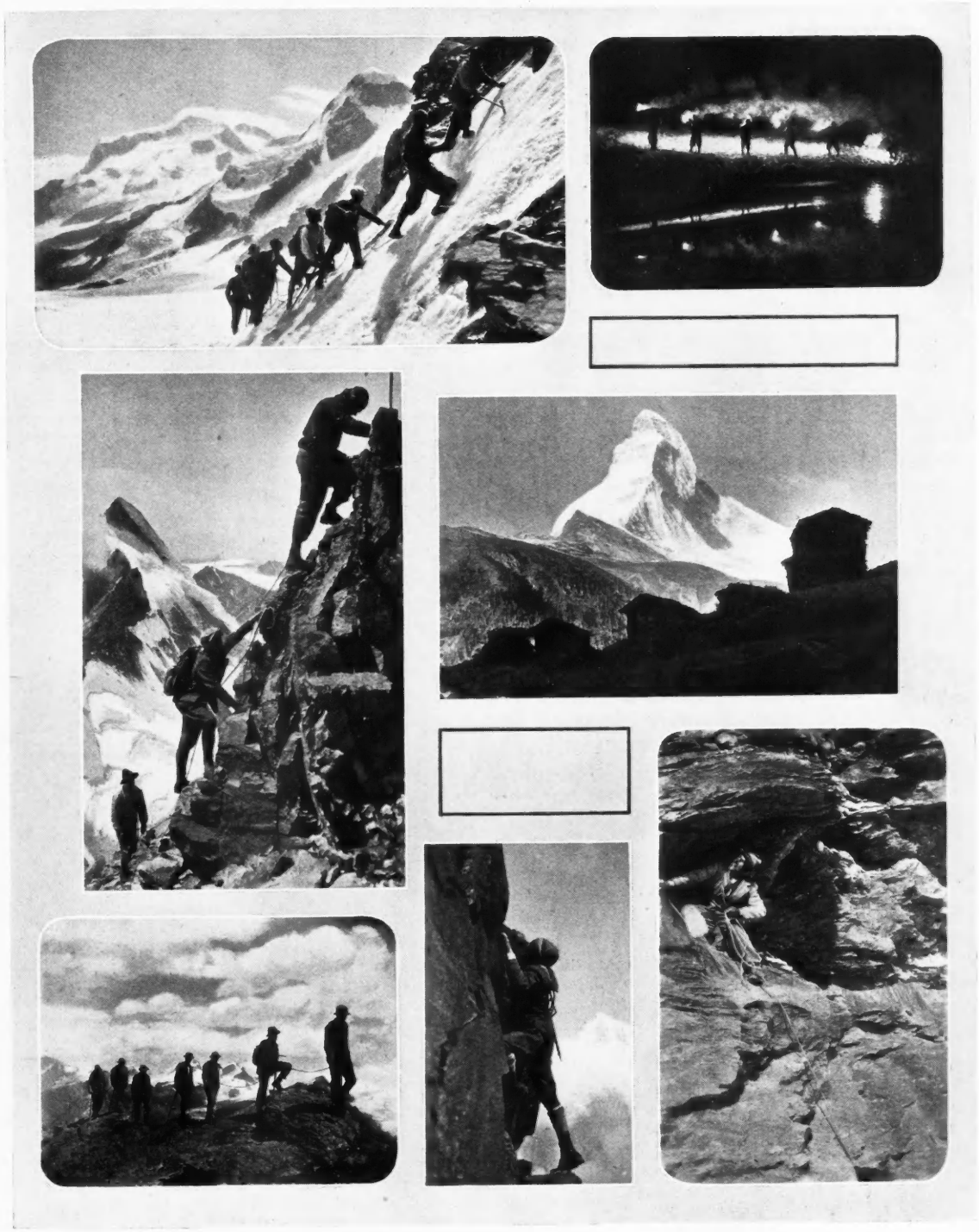
The Conquest of the Matterhorn.

THE story of the first climbing of the Matterhorn has now been recorded in a cinema film shortly to be released in Switzerland. Various scenes are here reproduced (page 11). In the Zermatt Museum can be seen a small portion of rope which recalls the tragedy of this first conquest by Edward Whymper. The great British Alpinist's name holds deep significance in the Swiss Mountains, where his memory is kept ever green by the splendid guides who have now reconstructed the story for the film.

Until 1865 the majestic Matterhorn had defied all climbers. But in that year, urged on by the knowledge that a well organized attempt was to be made by the Italian Government, Whymper attacked the climb, without special preparation, and succeeded. The victory was hailed as an event of international interest. Whymper had set himself the task of mastering the mountain as his life's objective. On his first attempt he had a bad fall, and was only saved from death by the chance intervention of a big boulder which held him from falling over the edge of a terrible ravine. Later, when back in London and recovered from the mishap, he learned that under the guidance of an expert Alpinist an expedition was preparing to attack Matterhorn from the Italian side. Whymper left immediately for Zermatt.

Under the leadership of Jean Antoine Carrel several Alpinists started from the Val Tournanche, on the Italian side, hoping to gain the laurels for the first ascent of the great peak. A day later Whymper, in all haste, set out with three English tourists, and three Swiss guides named Gross and the Taugwalders, senior and junior. After a tremendous climb with many a bad moment, Whymper and his party were successful. The Italians were beaten and retired to Breuil.

But success was not achieved without loss. The mountain claimed its toll. Owing to the breaking of the rope the three English tourists and the guide Gross were hurled into an immeasurable abyss to their death. The shock completely unmanned the two Taugwalders. Whymper wildly endeavoured to move them and start the descent, but they were numbed with terror. At last he had to drive them with his ice-axe. It was a terrifying experience, but eventually, held fast by the rope round the indomitable Whymper, they succeeded in reaching safety. The dramatic character of the story is well brought out in the new photographs.



WHYMPER ON THE MATTERHORN: THE NEW SWISS FILM.

How Did Britain's Racial Division Arise ?*

By Sir Arthur Keith, F.R.S.

Hunterian Professor, Royal College of Surgeons.

Evidence that has been accumulating for fifty years past now justifies a new theory as to the racial division of Britain four thousand years ago. The orthodox view of an east to west invasion must be broadened, in Sir Arthur's opinion, although there are still difficult problems to be solved.

LET me begin by asking a question : How comes it about that the western part of this island is separated into a country called Wales, while the eastern part is known as England ? The orthodox will reply that the separation came into existence a little over a thousand years ago as a result of an invasion which swept across the island from east to west. At the foot-hills of the west the invader's progress was stayed, and thus a racial frontier came into being. On one side of the frontier were established the ancient Celtic-speaking Britons ; on the other side the new Saxon-speaking Britons.

The Anglo-Celtic Frontier.

The line between Wales and England marks only a part of the old Anglo-Celtic frontier ; a thousand years ago that line was continued northwards through south Scotland until it reached the Grampians somewhere in the neighbourhood of Aberdeen. It was continued southwards to the east of Cornwall, and from there the line swept across the Channel to Brittany. Then still further to the west in these islands, there is another and older racial frontier line—that which separates the Welsh-speaking Celts, the Brythonic or " P " Celts, from the Gaelic-speakers, the Goidelic or " Q " Celts. Those who accept the usual teaching of history will regard the Gaelic-speakers as representatives of an early wave swept into the west by a Brythonic invasion, and this in turn moved onward by Saxon and Dane. Orthodox history, then, explains our racial frontiers by supposing that our islands have been inundated by successive racial waves, these waves originating on the continent and sweeping across our country from East to West.

The orthodox view has the great merit of simplicity. The theory I am to advance is not so simple ; it is still unorthodox but is steadily gaining adherents. It began to come into existence in the latter part of the nineteenth century when historians discovered that the study of caves, of ancient tombs, of prehistoric camps, and of sites of vanished villages, could carry our island story far beyond our oldest manuscripts and traditions. This new theory is not the preconception of a single mind ; it has been a gradual growth to which many minds have contributed. It was enunciated by Professor T. H. Bryce, F.R.S., so far as Scotland is concerned, in the *Scottish Historical Review* of 1905 (p. 275). No one has done more to extend and substantiate the theory I am to expound here than Professor J. H. Fleure of Aberystwyth.

What then is this new theory ? It is simply that this country of ours has two doorways of access—not only an Eastern but also a Western, and that in ancient times the western gateway was the more important. It will be realized that if one race settles along our western coasts and spreads inland and another race invades our eastern shores and expands, a time will come when contact is made and a racial frontier is established at the line of contact—a line running along the length of the country from south to north. Our new historian, then, interprets the racial frontiers of Britain, not as the troughs between successive waves flowing towards the west, but as the line of impact between eastern and western invaders.

What Caesar Found.

At first sight the case which the one-portal historian has to put up against us seems a very strong one. " Did not Julius Caesar," he asks, " when he reached the Straits of Dover in the year 55 B.C., find that waterway busy with traffic, and did he not obtain then the clearest evidence that there was, and had been for centuries, a stream of colonists from France to England ? " That, of course, is true. It is also a fact that during the four centuries of their occupation the Romans used mainly the Kentish portal. No less true is it that the Saxons, at least in the earliest phase of their invasion, landed in Kent. Now all these contentions are undeniable ; they are true of time and place. But we in turn may ask of the orthodox historian a question : What was happening during these long past times at our western portal—St. George's Channel ? He will probably reply that we

*The substance of this paper was recently given as a lecture to the Students' Scientific Society, University College, Aberystwyth.

cannot now tell; there is no evidence. This is where the new historian joins issue with him. During the past fifty years, evidence has been gathered on both sides of the Irish Sea, which leaves us in no doubt that for at least two thousand years before the time of Christ ships sailed through our western portal carrying colonists and culture to what is now Celtic Britain. The same process, as we shall see, had been going on simultaneously at our eastern gateway. This double-portaled conception of our country is not one you can take or leave with impunity; it is the key to our racial history; for through these two portals entered opposing streams of men and of cultures. We shall never understand the origin of our racial frontier until we have grasped the idea that East and West have met along the length of Britain.

The Influence of Ships.

Before I allude to the sources from which we have compiled a history of Celtic Britain, let me deal with one or two broad ideas which serve to guide us into the past. In 1890 Captain A. T. Mahan wrote a book on "The Influence of Sea-power on History." Mahan had in mind only recent centuries and the political power which a strong fleet gives to modern governments. He did not think of ships as the most powerful of anthropological instruments, but they are! Through ships and sea-power Western Europe has colonized a great part of the world in recent centuries and gained a dominant position in the racial constitution of mankind. Nor is it only in recent centuries that men have used ships for the purposes of colonization and expansion. Sea-power is no new thing. Thanks to the excavations made by Sir Arthur Evans in the island of Crete and by the army of archaeologists which has explored the antiquities of Egypt we know that as early as the fourth millenium before Christ ships were crossing the Eastern Mediterranean, exchanging the products of Egypt and Crete. Even then the open sea was becoming a human highway. In the millenium preceding the birth of Christ we find the Phoenicians masters of the Mediterranean, trading along its shores and colonizing its lands. We may be certain that the Phoenicians were not the first of the Mediterranean sea dogs; they must have had predecessors, for we find the shorelands of the Mediterranean, on the African as well as on the European side, occupied by men of the same type—that to which Sergi gave the name Mediterranean. I see no way of accounting for the distribution of a uniform human type, between the Levant and the Atlantic, except by presuming that men of the Mediterranean type discovered at an early date that the easiest road to new lands lay on the sea. They made ships a factor in the evolution of races.

Now towards the end of the third millenium B.C., a belief, probably acquired from the East, seized the Western Mediterraneans' mind, one which caused men to build permanent abodes for their dead. It is most fortunate for us that they chose such enduring material as stone for their tombs, for it is from them we must read the history of these distant times. By means of tombs we trace the spread of beliefs and of peoples. We find the megalithic tombs of the Western Mediterranean on the coasts of Spain; we know of a great belt of them which crosses France from the Mediterranean to Brittany. These tombs are not all of one kind or of one date; there is a succession of them. That succession we can trace onwards to south and west England, to Wales, to all the coastal lands of Ireland, and along the Atlantic seaboard of Scotland, right to the Orkneys. Thus by the study of ancient tombs we are able to establish the fact that during the second millenium B.C. ships were entering our western portal, carrying new men, new beliefs, new customs, and new arts. We also realize that the lane which ended at our western portal began in the distant East—the cradle of modern civilization. Thus did those ancient Mediterranean sea-dogs, by an early exercise of sea-power, obtain dominion in Western Britain. Professor Fleure has found their descendants amongst the people who live on the uplands and coast lands of Wales. Men of the Mediterranean or Iberian type still abound in many parts of Ireland, as in other parts of Celtic Britain.

Our Eastern Sea-board.

We have been taking a glimpse of Western Britain in ancient times through the archaeologist's telescope; I propose to turn that instrument on our eastern sea-board. I have given my reasons for believing that sea-power became a potent factor in the basin of the Mediterranean some five or six thousand years ago. When we turn to the north we find evidence that here, too, sea-power has been a factor in the distribution of races from remote times. The North Sea became a highway for invaders at a much earlier date than is usually suspected. Near the beginning of the Bronze Age, certainly 1,500 B.C., Danish warriors fully armed were buried in curious coffins cut out of tree trunks; on the coasts of Yorkshire, directly opposite Denmark, identical burials, containing similar warriors, have been found. To explain such discoveries it is legitimate to presume that these warriors crossed from Denmark to Yorkshire. When exploring a tomb, belonging to the early age of bronze and situated

in Southern Sweden, archaeologists discovered in the tomb a block of Aberdeen granite. Our main case, however, does not rest on such isolated items of evidence, but on the mass of information which has been gathered concerning the earliest colonization of Eastern Britain by a foreign people of which we have knowledge. Archaeologists are agreed that this colonization began about 2,000 B.C. It affected the whole length of our eastern coast-lands from Caithness in the North to the Isle of Wight in the South. These invaders are now known as the "beaker-people," because of the peculiar earthen drinking-cups they brought with them from Germany. They were people with strangely-shaped heads, rough featured, tall and powerful. The more we get to know of the facts of this invasion of Eastern Britain and colonization, the less possible is it to accept the late Lord Abercromby's opinion, that the movement was based solely on the Straits of Dover. We can explain what we now know only by presuming that about 2,000 B.C. the beaker-people had become masters of the North Sea and made direct landings on our eastern coasts at many points, where they set up settlements and buried their dead.

Successive Invasions.

What motives tempted these men across the North Sea? We may presume that they were actuated by the same motives which led our ancestors to set up colonies on the eastern sea-board of North America—a search for new homes—for land they could till, for they were a farming folk. The beaker invasion was not a single descent, but a succession of landings continued over a long period of time. We can trace the spread westwards of the new colonists; in Derbyshire and Shropshire we find this North Sea folk coming in contact with the people and the civilization of the west—derived from the Mediterranean. The beaker-people spread westwards, apparently becoming arrested at much the same line as that which limited the Saxon invasion more than two thousand years later. It is true that at certain points the beaker-people actually penetrated the west. Their tombs have been discovered and explored in South Wales; Mr. Neil Baynes found a true beaker skull in an ancient tomb in Anglesey; Professor Fleure has traced descendants of the beaker-people amongst men still living in the Bala cleft in mid-Wales. Yet the fact remains that this North Sea invasion was mainly confined to lands which afterwards became settled by Saxons. The dividing line between Wales and England is much older than the orthodox historian is inclined to believe.

How did those early invaders of east England, the beaker-people, come by their knowledge of sailing, of agriculture, of weaving, of pottery, and of other arts which they practised? In recent years much light has been thrown on this problem by the archaeologists of Europe—particularly by Professor Gordon Childe and Mr. Harold Peake. We have spoken of the sea route which led from the Levant to Western Britain; we are now realizing that there was also a land route which led across Europe from the distant East to the North Sea and onwards to Britain.

Culture from the East.

We need not inquire too minutely into the manner in which a route was established across Europe whereby the culture of the East reached the West. Professor Gordon Childe has found evidence that a knowledge of agriculture had reached that part of Western Europe, which is now Belgium, early in the third millenium B.C., and that it had spread from the East by the Danube route. He is also of opinion that it was brought by a round-headed people. Now our beaker invaders, although very different from the Neolithic folk of Belgium, had a form of head which does suggest an Eastern origin for them at some remote date. In the meantime it is enough for us to know that in the third millenium the light of the East was crossing Europe and reaching a people which had become established on the continental shores and estuaries of the North Sea. We also infer that this continental people became masters of the North Sea and ultimately of Eastern Britain.

Archaeologists are restoring to Britain missing chapters in her history—chapters which cover the two thousand years which precede the coming of the Romans. At the beginning of this period we find our land situated as the terminus of two great routes which led across Europe from East to West. One route—the Mediterranean—lay mostly on the sea, and debouched on our western shores. The other—the Central European or Danubian—was mainly a land route and debouched on the North Sea. Thus at this early period we find Britain divided into two spheres of influence, Mediterranean on the West and Central Europe on the East. Eastern Britain was an appendage of the North Sea, just as Western Britain went with the Mediterranean. Thus early did our racial frontier become established.

We have traced the descent of the beaker-people on Eastern Britain; let us see what we know concerning later invasions made through the same gateway. When did the Gaelic-speaking people come and by what portal did they enter? These questions bring us face to face with difficult and unsolved problems

for we must suppose that the original of the Gaelic tongue and the men who spoke it, were still in Central Europe at the beginning of the first millenium B.C. If they were Central European and thus on the land route which led to Britain, the Gaels ought to have entered by the Eastern gateway. Apparently they did not; scholars assure us there is no evidence that the Q-Celts were ever a North Sea people; no trace of them is to be found in Eastern England. To account for what we do know it is best to suppose that the people who carried Gaelic to Britain used only the Western portal, and established themselves on both sides of the Irish Sea. I am presuming that the Gaelic-speaking stock, although cradled on the route which led to the North Sea, trecked across France until it found itself on the Mediterranean route which led to Western Britain. Nor is such a supposition unlikely, for did not Julius Caesar find Central Europeans migrating in mass across Gaul at the close of the first millenium B.C.? Besides, in allocating Gaelic-speakers to the West, have I not the great authority of the late Sir John Rhys?

Peaceful Penetration.

Let us return to the Eastern gateway. The first coming of the beaker-people took place about 2,000 B.C.; what happened at the gateway between the coming of the beaker-people and 500 B.C. when the first invasion of the Welsh-speaking or P-Celts began to find their way to England we do not know. The Brythonic invasion was in reality a long process of colonization; it was still going on when Caesar arrived at the Straits of Dover. They were Celtic-speaking people who colonized Eastern Britain, but in the strictest sense of the term they were also a North Sea race being close akin to the Nordic stock of Europe—the same stock which at a later date gave Britain her Saxons. The Celtic-speaking Britons colonized all our Eastern lands, spread inland, carrying with them their speech and industries, until the Mediterranean west was reached. There I infer that a process of peaceful penetration ultimately took place, the Celtic tongue, Celtic industries, and Celtic manners passing into Wales and replacing those which were mainly of Mediterranean origin. Thus I regard the people of Wales as chiefly of Mediterranean or South-west European origin, who entered into their heritage by the Western portal of Britain, but the language they speak was acquired from the Celtic-speaking people who entered Eastern Britain in the five centuries before the coming of the Romans.

Finally we come to the last and greatest of the invasions which have been made through our Eastern gateway. I have applied the term "invasion" to the coming of the Saxons, but a series of landings, which extended over two centuries, cannot rightly be so named. The Saxon "invasion" was a true colonization for the immigrants brought with them their wives and children; they came sword in hand but not for plunder; mainly for a home. The Celts who colonized Eastern Britain spoke one tongue, the Saxons spoke another, yet the movement of the one was but a continuation of the other, the whole movement being broken into two parts by the occupation of Britain by the Romans. Each succeeding race of our invaders brought with it a more intense love of life and a more powerful culture than its predecessor. The Saxon invaders followed on the tracks of their Celtic-speaking predecessors until the Mediterranean West was reached. Against the Saxon colonization only Wales has stood firm and maintained her frontier intact. Western and Highland Scotland has slowly capitulated to the seductive wiles of peaceful penetration; Cornwall, too, has fallen, and yet I would not say that the Celtic spirit in these parts of Britain has been subdued by the Saxon tongue; it may slumber, but it is still alive in the descendants of the Celtic speakers and flames up on provocation. The Eastern frontier of Wales is the only part of the ancient racial divide of Britain which still persists as a sharply marked line.

National Problems.

In this short article I have attempted to cover four thousand years of British history. This feat is particularly daring on the part of one who is not an archaeologist, who is ignorant of the history of languages and of cultures, and who knows only a little of human races. But during these past forty years I have kept my eyes and ears open for all information which bears on the early history of our country and our people, and when one gathers facts it is impossible to resist seeking for a way of explaining them. One accepts or constructs the most likely theory which will account for them. Now, what I have been seeking to do in this paper is not to lay anything of my own before my readers, but to interest them in certain broad ideas which have grown up in the minds of those who are searching into the foundations of our racial history. And when these broader ideas have been grasped they will be found to give a new interest to modern history and a new interpretation to the racial and national problems which confront us now. Such problems, I dare think, will be best solved by those who have traced them back to their remote beginnings.

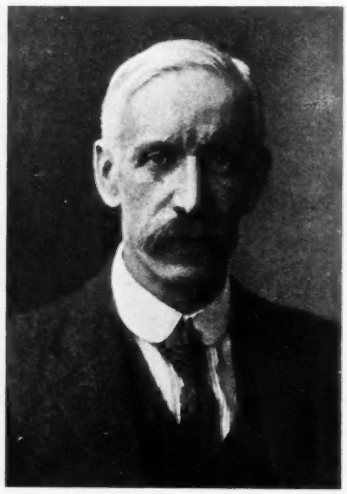
Vitamins and Sunlight.

By Mrs. Leslie Harris, B.Sc.

Progress in the study of vitamins, in particular from work at Cambridge, has lately been of marked significance, but much remains to be discovered about these essential substances. There is not yet sufficient evidence for many of the loose statements that sunlight and vitamins are equivalent.

THE term "bottled sunshine" was originally applied to coal and referred to the energy stored in it. Recently the term has been adopted by fruit growers' associations to imply that the vitamins contained in fruit derive their peculiar properties from the sunshine in which it ripens. The present article is intended to show how far the properties of the different vitamins are dependent on or identical with the powers of sunshine.

It is now known that rickets is caused by lack of vitamin D in the diet, and that it can be prevented or cured if an adequate supply of this factor is provided. It was, however, long maintained that not only good food, but massage, good conditions of living and plenty of fresh air, were just as potent as any actual "anti-rachitic agents" in preventing rickets. There was certain presumptive evidence for this view, as could be seen when one considered the large proportion of rickety children in the slums, compared with those who were fortunate enough to be reared under good hygienic conditions.



SIR F. G. HOPKINS, F.R.S.

The pioneer work of Professor Hopkins laid the foundations for the discovery of the vitamins. The Sir William Dunn Institute at Cambridge, one of the world's greatest research laboratories, is under his charge.

The unhappy conditions in Vienna during the years following the war made an investigation of this question not only possible but acutely necessary. A key to the solution of the whole problem was found by a band of English workers under the guidance of Dr. Harriette Chick, and in co-operation with the Viennese medical men. At this time not only were infants suffering from rickets, but adults too were afflicted with diseases which arose directly as a result of inadequate feeding. The English workers held the opinion that they could cure and prevent rickets by cod-liver oil alone. The Viennese, however, were dubious as to the efficacy of this measure by itself, for they were not prepared to accept the view that rickets was purely and simply a matter of vitamins. Their idea was to cure their patients by remedying the bad conditions under which they lived, ensuring that they had plenty of fresh air, and incidentally better food. Strangely enough, both bands of workers were able to produce clinical evidence in support of their hypotheses. Rickety infants to whom cod-liver oil was given were completely cured, but others who lived an outdoor life were also cured. It was then that Miss Chick and her co-workers advanced the hypothesis that the bright sunshine on the balconies where the children were treated by the Viennese doctors, could somehow replace a vitamin in the food. The explanation of these results is by now well known, but it was not until 1924 that the full relationship between cod-liver oil, vitamin D and good hygiene was completely demonstrated. About that date adequate laboratory evidence was obtained to show that the ill-effects caused by the insufficiency of vitamin D, could be remedied by exposing the experimental animal on the deficient diet to a source of ultra-violet light. Another important fact was soon brought to light by Dr. H. Steenbock and independently by Dr. Alfred F. Hess, who found that it was possible to "activate" a ration deficient in anti-rachitic vitamin by exposing it to light, thereby conferring on it ricket-preventing properties.

These experiments on animals were really, it will be seen, a confirmation of the results obtained in the clinical investigations by the Austrian medical men. For although they stated that they kept their infant patients in the fresh air, the important fact, as mentioned above, was that the infants were kept on sunny balconies, and it was the sunlight that was responsible for the many cures which were effected.

A further interesting phase in the solution of the problem was reached when, for a year or so, it was thought that the very air in an animal's cage if irradiated could supply its vitamin D requirement. In some experiments the empty cages, without the rats, were exposed to ultra-violet light : the animals were then placed in these cages and deprived of all vitamin D in their diet. They were found to thrive as well as animals on diets containing cod-liver oil, and it was thought that they were deriving their anti-rachitic vitamin in some mysterious way from the air they breathed—until it was shown that they were in the habit of eating the sawdust from the floor of their cages, and that this had developed anti-rachitic properties when the cages were irradiated.

The Latest Link.

It was soon discovered that various substances, including some foodstuffs, could be activated by exposure to ultra-violet light. Further analysis showed that cholesterol—a constituent of cod-liver oil and many foods—after exposure to ultra-violet light was much more potent in the prevention and cure of rickets than cod-liver oil itself. Now cholesterol, although a definite chemical compound, possesses a very complex constitution, and extreme difficulty is experienced in obtaining pure specimens. The latest link in this chain was forged less than two years ago when Dr. Otto Rosenheim and Mr. Webster, working at the National Institute of Medical Research, under the auspices of the Medical Research Council, and in collaboration with a German chemist, Professor Windaus, showed that it was an impurity in the cholesterol which was activated by ultra-violet light. Almost simultaneously identical conclusions were reached by independent investigators in America. This impurity was found to be ergosterol, a complex chemical compound of a waxy nature. Irradiated ergosterol is the substance which is now on the market under the names of " Radiostol," " Vigantol," etc. Although irradiated ergosterol in minute doses (one or two milligrams a day) is a potent preventative and cure for rickets even when no vitamin D is present in the diet, yet the chemical nature of the vitamin still remains unknown. It is known that there is no complete transformation of ergosterol into vitamin D under the influence of ultra-violet light. Probably other substances are formed too ; of their nature little is known. Possibly they may be toxic to animals and human beings, and so probably is the vitamin itself, if taken in colossal over-doses.

It has also been shown that if ergosterol be rubbed into the skin and the part of the body then exposed to ultra-violet light, the ergosterol, which thereon, of course, develops anti-rachitic properties, passes into the body and is therefore able to protect the animal from rickets. This observation and other similar considerations may be taken as a proof of the fact that when the body is exposed to sunlight or ultra-violet light, it is the ergosterol present in the skin which becomes activated ; and we can now see how sunlight is able to take the place of vitamin D in the diet. Thus the results of subsequent investigations have furnished an explanation of the clinical observations made in post-war Vienna.

Other vitamins have sometimes erroneously been supposed to be related to light in a similar way. It is often stated in books on infant welfare that infantile scurvy—or " scurvy-rickets," a disease due to deficiency of vitamin C—is commoner during the dull winter months than during the bright summer. This fact is quite true, but the reason for it is not always correctly given. Vitamin C is present in fresh fruit and vegetables and grass. When cows are fed on grass, as they are in the summer, their milk contains a fairly adequate supply of anti-scurvy vitamin. But during the winter when the diet of the stall-fed cows is poor in vitamin C, their milk is correspondingly affected, and any infant fed on winter cows' milk only would in all probability be receiving an inadequate quantity of vitamin C. It has been shown by Mr. P. Eggleton and Dr. L. J. Harris that sunlight has no influence at all on the formation of vitamin C in plants, and that it is of no value in curing or preventing scurvy.

Growth Promotion.

Another vitamin which is present in the green shoots of young plants is vitamin A—the so-called " growth-promoting " vitamin, essential to the well-being of all growing animals. The presence of vitamin A in the young shoots was for a long time assumed to be connected with the process of photo-synthesis. It seemed somehow a natural relationship, but it has recently been convincingly demonstrated by Dr. Thomas Moore that shoots grown in the dark (" etiolated ") are just as rich in vitamin A as those grown in sunny places. His experiments were carried out by feeding rats, themselves reared and kept in the dark, on wheat shoots similarly grown, and comparing their rate of growth with that of animals fed on ordinary green shoots.

It can be seen therefore that in many cases there is no scientific experimental basis at all for the loose statements which are made that sunlight and vitamins are equivalent. Only in the case of vitamin D has the relationship been shown to exist.

An Expedition to Mackenzie River.

By Kenneth Mellanby.

A journey made from Edmonton in Alberta through the North-west Territories provided the writer with picturesque impressions of life in Arctic Canada. A principal object of the expedition was to study the Red Indians now rapidly becoming extinct.

DURING the summer of 1928, Professor Ruggles Gates, of King's College, London, and the writer made an expedition to the delta of the Mackenzie River, in Canada. The northward journey started from Edmonton, till recently a trading post of the Hudson's Bay Company and now a flourishing city. We went by train—the only line of the Alberta and Great Waterways Railway—to Waterways, on the Athabaska river, and about 300 miles north. From Waterways we went by boat to the delta, 1,750 miles, with a portage of ten miles on account of the dangerous rapids between Fort Fitzgerald and Fort Smith. The delta of the Mackenzie River is 70° N. and 135° W., well within the Arctic Circle. The purposes of our expedition were twofold, botanical and anthropological. An extensive collection of flowers was made, and has been sent to the Herbarium at Kew for identification. Also Dr. Gates examined the Indians and Eskimos, and investigated their blood groups. All human beings (and also anthropoid apes !) can be classified as possessing blood belonging to one of four groups. The group to which a man belongs is determined by the action—or non-action—which two serums A and B have upon his blood.

THE S.S. *DISTRIBUTOR*.

The ship on which the writer made part of the expedition is seen behind the scow, from which unloading of freight is here in progress at Fort Providence.

If his blood clots with A serum, he belongs to A group ; if with B serum, to B group ; if with both serums, to group AB, and if with neither, to zero group. All North American Indians previously tested had belonged to group zero, and Dr. Gates was able to show that the Mackenzie River Indians agreed with this. The Eskimos, however, appeared to belong to group B, which would indicate that they are not as closely related to the Indians as is usually thought.

The train from Edmonton to Waterways runs once a week, starting its northward journey on Thursdays. Scheduled to leave at 9.30 a.m., it pulled out shortly after 10 a.m., which was remarkably punctual for this railway. The train was well over a quarter of a mile long, and had nearly sixty separate trucks on it. There were the three passenger coaches at the rear, and in front were many freight cars, the whole being pulled by one engine. When the train started, there was such a shock that we just collapsed, thinking the Trans - Canada express had hit us ! But this was the usual method of starting and of stopping, and the train stopped every few miles for no apparent reason. The maximum speed attained was 20 miles an hour. We expected the train would soon go on again, but on looking out we saw the crew standing round gossiping. When they had no more to say, the train was allowed to continue.

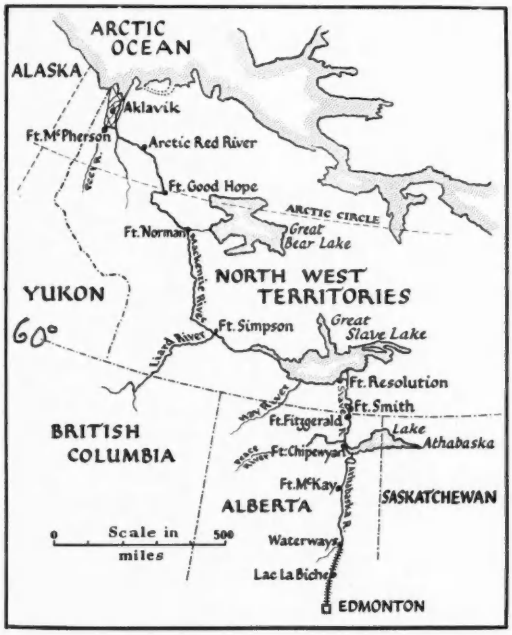
That evening we reached Lac la Biche, having done 120 miles in ten hours. This town had 300 inhabitants, who spoke thirty-seven languages, both European and Indian. After a four hours' stop there, we continued our run. All along the banks were dense woods of poplar, birch, and conifers, with a very varied collection of flowering plants, of which we made numerous collections, thanks to the erratic running of the train ; one interesting flower was the blue delphinium, so common in British herbaceous borders, growing here wild in great abundance. There were numerous flowers which are also found in other parts of Canada, but which were quite new to the writer. Next day at noon we reached Waterways, having run 300 miles in twenty-six hours !

Waterways has a station, two offices and a wharf,

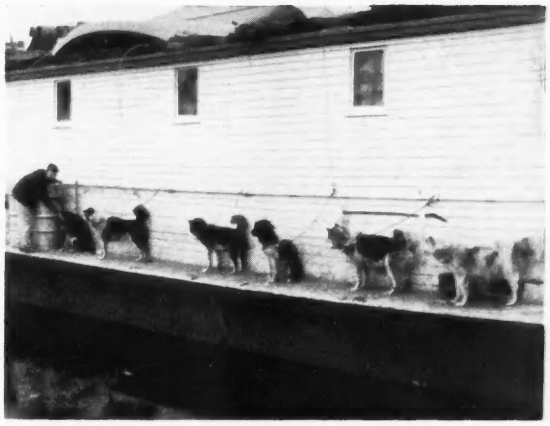
and we had expected to be met by the S.S. *Athabaska River*, to convey us to Fort Fitzgerald, but were casually informed that it was not in; it might arrive that night, and would leave on Monday. We felt a little lost, and wondered where to eat and sleep. Some time later a very old Ford ton truck arrived, and the driver, a lady in masculine attire, said she would convey us to Fort MacMurray, three miles distant. I shall never forget that run. The road was just a cleared part of the bush, and was so rough that we spent more time in pushing the vehicle out of holes than in riding. But at last we reached Fort MacMurray, which had an hotel—a large log building—and other buildings in various conditions of disrepair.

Early on Monday morning the S.S. *Athabaska River* left Waterways, and completed the 400 miles to Fort Fitzgerald by Wednesday noon. It went down the Athabaska River to Lake Athabaska, and after crossing the lake, went down the Slave River to Fort Fitzgerald at the head of the Slave Rapids. The Athabaska is only a small tributary of the Slave River, which is mainly fed by the Peace. Below Fort Smith, the Slave River runs into Great Slave Lake, which drains into the Mackenzie River.

The S.S. *Athabaska River* and the S.S. *Distributor*, aboard which we completed the journey below the portage, were much alike, and the photograph, which is of the *Distributor*, could be that of either. These



MAP OF THE AUTHOR'S EXPEDITION.



"HUSKIES" ON THE SCOW.
These sledge dogs were chained to the deck of the freight scow and howled continuously throughout the river voyage.

boats are propelled by a stern paddle, and wood is used for fuel. The wood is taken on at wood-piles along the river by the Indian deck hands, and twelve per cent of the time taken on the journey is wasted at these wood-piles. But while the others were bored by these waits they were very convenient for the botanist, and at each wood-pile we collected all we were able. The lower deck of the boat, which is just above water level, is filled with freight, wood, and the engines. In front of the boat a large scow was pushed, and it was well laden with more freight. The passenger accommodation was confined to the deck, on what might be called the first floor. In front was a saloon, furnished mainly with cuspidors. Behind was the eating room, which had no windows, and the cabins were round about it. We took half a dozen steers with us on board, for meat is unobtainable, and there were a varying number of "huskies," or sledge dogs, chained up to the scow, which dogs howled continuously. The only amusements provided were two cribbage boards and a "gramophone" played by turning the records round with one finger!

Fort McKay was our first stop. This is a very deserted place, with a Hudson's Bay Company store and a few Indian teepees. This is not a characteristic "Fort." Usually there was a Hudson's Bay Company trading post, and one of the opposition company, the Northern Traders. At most places there was also a "barracks" of the Royal North-west Mounted Police, with two men, and usually either an Anglican or a Roman Catholic mission. From a distance some of the posts looked quite large, due to the few additional tumbled-down shacks of the more civilized Indians. At Fort Smith, Fort Simpson and Aklavik there are wireless stations, with three army signallers

in charge. There are about 100 white men in the entire Mackenzie district, most of whom are trappers and whom we never saw.

The banks of the Athabaska River are covered with poplar and spruce. In places we could see the bituminous sand, which occurs very abundantly, and will some day be exported for road making. Lake Athabaska contains a great deal of fish, and trout, mostly as large as small salmon, are netted and sent out packed in ice saved from the winter; these fish were amongst the most delicious I have ever tasted. Fort Chipewayan, the base-camp from which Alexander Mackenzie explored North-west Canada, is situated on the north of Lake Athabaska. This was the only spot in the north where we found any true ferns growing. On leaving the post, we entered the Slave River, named after the Slavi Indians.

There are very dangerous rapids between Fort Fitzgerald and Fort Smith, and we made a portage of fifteen miles, and embarked on the S.S. *Distributor*. Round about Fort Smith the ground is bare, and the dominant plants are a creeping potentilla and wild barley (*hordeum jubatum*)—grasses are not abundant. Although the plains buffalo (*bison bison*) has been exterminated except as a domestic animal, the woods buffalo (*bison bison athabaskae*), a larger and finer beast, is still found wild near Fort Smith. As the plains buffalo at Wainwright Park are very prolific, the Government found themselves unable to cope with them, and, despite the protests of the Canadian naturalists, sent the surplus into this area, where it is feared they will exterminate their finer but less prolific relations.

Insect Pests.

On Sunday evening we started once more on a journey of 1,300 miles. The two insect pests we met were the bulldogs and mosquitoes. The bulldogs are biting flies, allied to the horse-fly, as large as bees, and in places extremely abundant—the windows of the *Distributor* were black with them. At Fort MacMurray the mosquitoes were very troublesome, but as we went north, a little way back from the river, they were so thick that a veil and gloves were essential, and even then they would bite through our clothes. Botanizing is not as easy as it sounds when there are myriads of mosquitoes hungry for one's blood—the only consolation is that these are not malarial.

Some 150 miles below Fort Smith, the Slave River forms a delta and runs into Great Slave Lake, the fifth largest lake in Canada. The delta is very flat, and has so many channels that men have been lost in it. The river banks are flat and muddy, with horsetails (*Equisetum*) under foot, and a thick scrub of willows, which bushes are welcome, for the mosquitoes do not seem to like them. The water in the delta is very shallow, but the channel is obvious, due to the large quantities of driftwood stranded in the Shallows; all along the banks there was a large quantity of driftwood, but in too irregular logs for the boat to handle as fuel. The travellers in winter make use of a small fraction of it.

Forest Fires.

Forest fires do much damage in this area, not so much to the grown timber, which is still useful, but in killing the seedlings. In burnt areas, the whole ground was covered with the purple fireweed (*epilobium angustifolium*), and very little else. As yet, the forest of the North-west has not been exploited. Spruce is the dominant tree, with willows at the river's edge.

We saw many Indians at the posts, with such picturesque names as Dogribs, Yellow Knives and Slavi, but they did not impress us. They seemed very dirty, and rather unintelligent. This year over ten per cent have died from influenza, partly due to their bad physique, and partly due to their disregard of instructions from the Mission workers (who have done heroic work). When Dr. Gates did a blood test on a sick man, the patient usually felt better as a result! Most of the Indians belonged to blood group zero, and those who did not usually showed other signs of white blood.

At Hay River, on Great Slave Lake, there is a large Anglican Mission, with some Eskimo children from the delta 1,000 miles away. Here Dr. Gates and I were very courteously received, and were able to do many blood tests, and take photos of the children so tested. There was also an interesting flora, with an extremely rich selection of willows. It was evening when we left Great Slave Lake, and entered the Mackenzie River, and there occurred a most beautiful sunset. The river was about ten miles wide, studded with little islands, some covered with dark spruce and some with moss ten feet deep, and in the distance, the Rocky Mountains were visible. At 9 o'clock the sun went down, and until 11 o'clock the sky was a blaze of ever-changing colours.

The banks of the Mackenzie were much the same all the way down, except that the tall spruce at the south were replaced by very small ones in the north. The flora varied a good deal, and among the most striking features were the "lawns" of equisetum.

Just before entering the Arctic Circle, we went through the Ramparts, a gorge, seven miles long,

with cliffs 200 feet high, surmounted with dwarf spruce. At Fort Good Hope, on the Arctic Circle—here the sun set at 11 p.m.—the 'flu was very bad. Here there were a number of Arctic plants, such as a large blue gentian, the other epilobium (*c. latifolium*), and a variety of cushion plants on the "beach." Leaving Fort Good Hope, we crossed the Arctic Circle. There was no snow visible, but all this region is perpetually frozen below two feet. The dragon flies were very numerous, and very beautiful—the natives call them mosquito hawks. They earn their name well, and kill many mosquitoes, but we wished they were a thousand times as plentiful.

Next we came to Arctic Red River, a dismal place, and resounding with the howls of the "huskies" or sledge dogs. These dogs are chained up all summer, so that they will not fight. The sole diet of the dogs is fish, caught in nets in the river, split, dried and smoked, so that it looks like "finnan haddocks." In winter, two dog teams will travel together, and one will be loaded with fish for food.

The last stop the boat made was Aklavik, in the middle of the delta. It is a new place, and had quite a flourishing appearance. There were a number of Eskimos at Aklavik, mostly living on their schooners, as the motor-boats they own are called. The Eskimos are a thrifty and economical race, with a much higher intelligence than the Indians, and it is the ambition of every Eskimo to own a schooner! They still wear their parkas, or tunics with hoods, wearing in summer light ones, and in winter parkas made of the heaviest furs, for the Eskimo can stand the cold no better than the European.

From Aklavik Dr. Gates and I went on a motor-boat twenty-five miles north to a piece of tundra easily accessible. The boat was worked by Lucian, a clean and extremely intelligent Eskimo. We landed, and waded ashore through mud, on which grew the usual equisetum. Then there was a zone of willows, a quarter of a mile wide, and free from mosquitoes. Inside the willow zone was the tundra, stretching for miles, up to the mountains and to the north coast. It was bleak and bare, with no trees at all—there were dwarf birches and willows about a foot high. The main plants were lichens (or reindeer moss), of which we collected a dozen species, true mosses, and grasses. In the damper hollows, cotton grass (particularly *errophorum polystachium*) was very abundant and luxurious. We also found club moss (*lycopodium selago*) abundantly, and quite a varied flora, though far fewer species than would have been found in the same area further south. All around the mosquitoes hummed like angry bees, and seemed particularly vicious. Cariboo are plentiful, but we saw none—we saw little through our nets but mosquitoes.

FOREST FIRE NEAR FORT SMITH.
The chief damage of forest fires is in killing the seedlings, the grown timber is often not much affected.

A WOOD-PILE ON THE MACKENZIE.
From such piles the timber is loaded on to the steamers for fuel, much time being wasted by frequent stops for this purpose during the voyage.

On our return journey to Aklavik, a wind sprang up, but this had little effect on the motor-boat, which was very steady. But we came upon a canoe—the only sign of human life we saw—containing a white trapper, an Eskimo, and an Eskimo boy. The canoe was in great trouble, shipping water continuously, so we took the people on board and were able to give them something to eat.

From Aklavik we went south again. The journey was made quicker, although we went against the current, for we stopped only a short time at each post. We made further collections of plants at the wood-piles, so we had quite a lot of material when we reached Edmonton again, at the end of our expedition.

The Electrification of Ireland.

By H. J. Shepstone.

A power-station, almost equal in output to those plants at Niagara, is now nearing completion on the banks of the Shannon in Ireland. Quite apart from its interest as an engineering feat, it is a bold attempt to solve a great economic problem. By means of cheap power it is hoped to bring greater prosperity to the country.

On the banks of the Shannon, Ireland's largest river, there is now rapidly rising a colossal power-station. The damming of a great waterway, the excavation of canals as wide and as deep as an ordinary river and the erection of a power-house far larger than any existing in the British Isles are necessary to accomplish this task. Furthermore, this work has had to be carried on without interfering with the existing traffic of a busy river. In the winter there have been stern battles against floods, when years of toil and costly machinery have only been saved by herculean efforts on the part of the engineers and their men.

An Economic Experiment.

This great engineering feat, which will demand an expenditure of £5,200,000, represents an important economic experiment. The whole of the Irish Free State is to be electrified from a common centre and from a single stream. From a point on the River Shannon electrical energy in the form of light, heat, and power is to be available by overhead wires for every town and village, factory, home, and farm. No one realizes more than the Irish people themselves that political freedom is a mockery unless it rests on a sure economic foundation. The great problem of Ireland to-day is to find employment for her rapidly increasing population. Exhortations to her farmers to produce more, to labourers to work harder and to the public to buy home-produced goods have been found insufficient. The position has become so acute that only by a transformation of the land, coupled with an entirely new outlook, can the problem be solved. This is what the Shannon Scheme is to accomplish—to transform an impoverished land into one of general prosperity.

When the British Board of Trade, in 1918, appointed a committee to investigate and report upon the water-power resources of the United Kingdom, a sub-committee was set aside to deal with the matter in respect to Ireland. The latter strongly recommended that something practical should be done in giving Ireland cheap electrical power. On account of the political unrest prevailing in the country at that time, however, nothing was done.

Hardly had the Irish Free State become independent, however, when the well-known German contractors, Messrs. Siemens-Schuckert, approached the Irish Government on the question of electrifying the whole of the country from a single hydro-electric power-station to be erected on the River Shannon, near Limerick. They offered to carry out the necessary investigations, and to submit a definite scheme for the consideration of experts to be chosen by the government.

Their report was received in September, 1924, and was passed for consideration to a committee of four experts called together from Stockholm, Zürich, and Christiania. During the following months a committee of experts carried out a detailed survey of the River Shannon, and finally reported themselves to be in favour of the project, subject to certain modifications. A bill was then introduced into the Irish Parliament requesting power to carry out the scheme. At first it met with considerable opposition, particularly from the local industries and the peasantry, but it was ultimately passed and a contract with the German firm was signed in August, 1925.

90,000 Horse-power.

Between Killaloe, a small town on the southern end of Lough Derg and Limerick, the River Shannon in its progress towards the sea falls about 100 feet. This fall is being utilized for power purposes by constructing a dam across the river at a point between Killaloe and O'Brien's Bridge. By means of this barrier the river will be diverted into an artificial channel, or "head-race" canal, which is being dug across the country to Ardnacrusha, a village three miles north of Limerick. At Ardnacrusha the water from the canal will pass through sluice gates to the power-house, now in course of construction. The capacity of the plant will be 90,000 horse-power, capable of generating 153 million units of electricity in the dryest year, 268 million units in a normal year, and 373 million units in a wet year. But the plant will be so designed as to be capable of subsequent expansion to a capacity of no less than 180,000 horse-power. This is equal to the output of the largest of the Niagara power plants, and it certainly looks as if

GENERAL VIEW OF THE POWER-HOUSE SITE ON THE SHANNON.

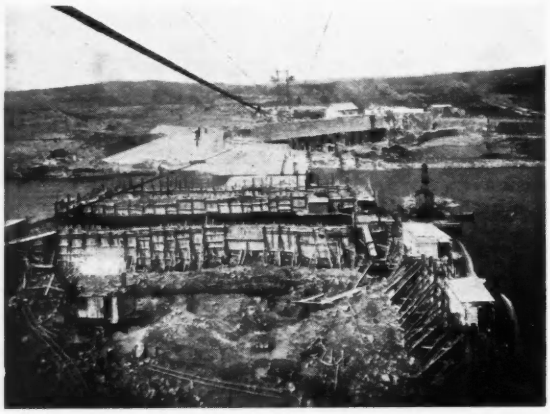
Here are seen the intake building, draught pipes supports and the power-house foundations at Ardnacrusha. The intake building, running across the head-race canal above the power-house, is essentially a concrete gravity dam or barrage. It is a massive structure 320 ft. long with six inlets admitting the water to the 19 ft. 6 in. penstocks. Only three of the inlets will be used at present.

Ireland is to possess the largest hydro-electric station outside America.

As soon as the contract for the undertaking was signed an electric derrick crane and two movable oil engine cranes were erected at Limerick harbour to provide adequate facilities for receiving the plant. The huge collection of material that in due course arrived from Germany included no fewer than eighty-three locomotives. Powerful tractors were requisitioned to haul the heavy machinery from the harbour to the various building sites. The peaceful country village of Ardnacrusha quickly became a centre of great activity. Two camps, one to accommodate 750 Irish workmen and one for German workers, were erected in the vicinity, and included concrete huts, large enough to house ninety men, and smaller ones of wood. Electric light was provided throughout, and large stoves were installed for heating the dwellings during the winter months. Extensive engineering repair shops, including welding and tool-making departments, and also a smithy were built, and a large storeroom was erected to hold a comprehensive stock of parts for every kind of machinery utilized. A temporary electric power station was constructed and nine Diesel engines, giving a total output of 4,180 horse-power, were installed. From this station power is also carried across country to the place selected for damming the river—a point near Clonlara, about two miles above the village of O'Brien's Bridge. Camps for workmen were built at both these places. Though not as large as those at Ardnacrusha, they were similarly equipped and had good recreation facilities. At O'Brien's Bridge the contractors took over an old disused mill and equipped it with central heating to render it inhabitable.

Along the route of the artificial waterway enormous excavators and transporters are carving out a valley and raising huge embankments by the removal of more than twelve million tons of earth. Leaving a short natural barrier of earth at the point where the waters of the Shannon are to be deflected, the canal is being cut from the western bank of the river in a general south-westerly direction to Ardnacrusha, following as closely as possible the contour of the hills situated to the west of O'Brien's Bridge. Excavation is proceeding simultaneously from the other end also, and more than half of the canal is already completed.

Six multiple bucket excavators, each capable of removing 13,243 cubic feet of soil per hour, are engaged in scooping out this channel, literally digging a bed for a river by machinery. They are operated by electric motors supplied with current by means of a



CONSTRUCTING THE DAM.

This dam when completed will deflect the waters of the Shannon into the head-race canal. It is being constructed in sections by means of coffer-dams, one of which is shown in the fore of the photograph. Here the men are seen excavating for foundations, protected from the water by walls lined with sheeting.

cable running parallel with the track. As the work progresses the steel rails along which the mechanical excavators and the soil trains run are moved forward by means of a great track-relaying machine. This device picks up sections of rails, already bolted to sleepers, swings it forward and by means of long, overhanging arms lays it on the roughly-prepared bed ready for the train to follow. A great deal of rock has to be removed, some 1,530,000 cubic yards to be precise; and this is being effected by boring and blasting. Excavation is only necessary for a part of the canal depth, the remainder being built up by embankments. This is being accomplished by the aid of electrically-operated transporters, said to be the largest of their type ever used in Europe. Soil trains tip the earth of which the embankment is formed into a trench behind the transporter. At the rear of the latter is a double chain of buckets. These are lowered into the trench and scoop up the earth which they shoot into the storage hopper at the base of the machine. From here the material passes by means of a conveyor belt up the jib, to be released and dropped at the desired spot. It may be deposited close to the transporter or at any point within the radius of the jib, namely, 130 feet.

The height from which the material is dropped helps to pound it together and thus render the bank more solid. When an embankment has been built up in this manner to the required height, it is allowed time to settle, after which the slopes and crest are dressed manually, and a covering of soil is then laid on to a depth of about eight inches. The tops of the embankments are approximately ten feet in width. Adequate steps are being taken to ensure that the canal is made watertight; where the soil is deficient a layer of clay two feet in thickness is added to the surface. As a further protection the bed and the inner slopes are lined with a layer of broken stone, roughly sixteen inches in thickness, obtained from rock cuttings at Clonlara. Then over an area, from three and three-quarter feet above high water level to one foot below low water level, a covering composed of concrete slabs is being laid over the broken stone to protect the banks from the erosive action of waves set up by the wind or passing vessels, for the waterway is to be a navigable channel.

This artificially-built waterway crosses several roads and streams and also intercepts the River Blackwater, a tributary of the Shannon. Usually the Blackwater is a modest, peaceful stream, but during the rainy season it becomes a raging torrent, and on this account special attention has been paid to it. By means of a huge concrete culvert the Blackwater will flow beneath the canal. Where the excavated channel intercepts roads the latter are being carried over it by means of reinforced concrete arch bridges, while small streams crossing the canal route are conducted underneath by means of culverts or syphons. The canal will have a total length of ten miles, and is certainly no make-belief stream seeing it is thirty feet deep, 100 feet wide at the bottom, and 327 feet wide at the top.

The Great Dam.

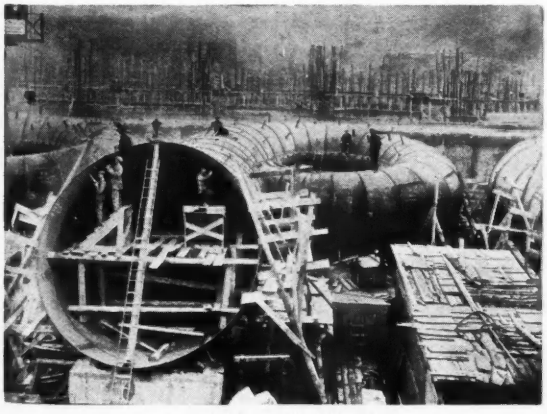
The great weir or dam by which the waters of the Shannon will be deflected into the canal will raise the water level of that section of the river above O'Brien's Bridge by some twenty-four feet and of Lough Derg by more than three feet. This will result in the formation of a lake, and enable sufficient water to be stored up to maintain a satisfactory flow into the canal throughout a dry summer. As it is necessary to keep the river open to navigation until the new channel is ready, the dam is being built in sections. The bed of the stream was first cleared of any loose earth and stones, and when the diver reported such to be the case holes were then bored in the rock and strong upright beams were inserted into them. To these were bolted strong sheet pilings forming a wall rising well above the river around the section. From the coffer-dam thus formed the water was pumped out, leaving this portion of the bed of the stream dry and thus enabling the men to secure the foundations for the dam.

The Shannon is an erratic stream and in the winter is liable to floods. Last winter the engineers were called upon to carry on a stiff fight against the rising

waters. As a result of particularly heavy rains the river rose unexpectedly high, and late one evening the whole camp had to be summoned to do battle against the rising waters. All the available sandbags were hastily dumped along the edges of the coffer-dam, thus raising it several feet. But the waters gradually crept up, and more bags had to be filled and hurried to the scene. All night long the contest continued, more sandbags being added as the waters continued to gain in height. Towards morning, however, the river began to fall and the engineers breathed a sigh of relief. Next day men were working in the coffer-dam thirty-six feet below the level of the river outside. It had the appearance of an island in the midst of extensively flooded country.

At Ardnacrusha, at the other end of the canal, work on the power station is being pushed forward day and night. Spanning the site are a number of cables suspended from steel towers 130 feet in height. These cables convey the material, such as concrete, to the desired spot, and also carry the powerful arc lights by which the scene is lit up at night. The concrete of which the power-house and the sluice house are being built is mixed in two huge machines. Each can make thirty-five cubic feet of concrete in three minutes. As fast as it is made it is swung through the air in skips by means of the cables to the required site and there discharged.

The power-house is expected to be finished early this year. Water from the canal will then pass into the sluice house, where there will be a screen 303 feet in length equipped with a mechanical cleaner to prevent pieces of wood and other matter being carried down through the penstocks to the turbines. The penstocks are huge pipes, nineteen and a half feet in diameter, through which the water drops down nearly 100 feet on to the turbines, which it sets in motion. They in turn will start the generator shafts in operation in the power-house above by which the coveted electric energy is generated. At present only three turbines are being installed, capable of generating 90,000 horse-power; but the plant is being so designed that another three can be added later, giving a total output of 180,000 horse-power, as already mentioned.



BUILDING THE PENSTOCKS.

These penstocks will carry the water down to the turbines in the power-house. They are 19 ft. 6 in. in diameter, and through them the water will drop nearly 100 ft. on to the turbines.

The consumption of electricity in the Irish Free State is now only 17 units per head of the population against 1,150 units in Canada, 1,000 in Switzerland, 710 in the United States, 318 in Belgium, 282 in Great Britain, 250 in France, and 195 in Italy. To what extent factory, shop, house and farm will take advantage of the new power remains to be seen.

Water Power in Scotland.

SCHEMES for hydro-electric power in Scotland are the subject of two private Bills to be promoted in Parliament. The resources involved are in Galloway and the West Highlands.

In the first area, *The Times* states, it is proposed to utilize the power resources of about 400 square miles of the watershed of the River Dee in the south of Scotland. It has been devised to fit in with the main transmission system of the country and to be operated so as to deal with seasonal and daily peak loads of upwards of 100,000 horse-power. The total available power is not concentrated at one spot, and its efficient development, therefore, involves the construction of five small stations, which have been so arranged that the water discharged from the upper stations can be utilized successively by the lower stations, together with the water collected from the lower catchment areas. The largest of these will be the Tongland power station at the mouth of the Dee, not far from Kirkcudbright. This will contain machinery of 48,000 horse-power, and will operate at a head of 100 feet.

The other scheme, located in the West Highlands, is based on Loch Quoich in Inverness-shire, which is to be made the storage basin of an area of about 200 square miles in one of the wettest regions of the Highlands. By leading the water by a tunnel down to sea-level at the head of Loch Hourn, the engineers have secured at once a head of nearly 600 feet, and a site for the principal power station accessible to ocean-going transport. The whole scheme will have a continuous output capacity of 50,000 horse-power. The engineers for both schemes are Sir Alexander Gibb and Partners and Messrs. Merz and McLellan.

Correspondence.

ENNERDALE WATER.

To the Editor of DISCOVERY.

SIR,

The interesting article on "Ennerdale—A Problem for Geologists," by Dr. Gurney, in your December issue challenges comment from geologists. He points out that it is difficult to account for the existence of *Limnocalanus macrurus* in Ennerdale Water—either by supposing that Ennerdale is a relict of a great Irish Sea lake or of a great marine submergence.

Having been engaged with my colleagues in the geological resurvey of the Ennerdale area in recent years, I would like to offer a suggestion. I would first point out, however, that Dr. Gurney does not appear to have considered the suggestion put forward by Professor Hogbom for the relict faunas of those North German lakes that are outside the area of the Ancylus Lake. Professor Hogbom argues that marine waters were impounded against, and pushed forward on to the land to the south by the Baltic Glacier during its readvance. On the retreat of the ice a series of lakes were left in which certain constituents of the marine fauna that had survived the successive changes to brackish and fresh water continued to flourish. Independently, Professor Charlesworth has developed a similar explanation for the relict fauna of Lough Neagh (*Geol. Mag.*, 1928, p. 212).

For Ennerdale, excluding, as Dr. Gurney does, accidental and migratory origin, there appear to be three possible explanations of the occurrence of *Limnocalanus* :—(*a*) Ennerdale is a relict of a great post-glacial Irish Sea lake ; (*b*) Ennerdale is a relict of a marine submergence ; (*c*) The sea was driven inland by a readvance of the ice.

To satisfy the first hypothesis a very great crustal warping of the Ennerdale area is needed to permit an extension of this finally fresh water lake from a level of many fathoms below present O.D. to Ennerdale which is now at nearly 400 feet O.D. There is no geological evidence in support of this hypothesis. In the case of the second hypothesis geological evidence is definitely opposed to such late or post-glacial submergence.

There remains the third hypothesis. The recent resurvey (Summary of Progress for 1921 ; *Mem. Geol. Surv.*, 1922) has brought abundant evidence of a readvance of ice from the sea on to the coastal areas of Cumberland at a late stage in the Glacial Period. This has been correlated with the readvance utilized by Professor Charlesworth to explain the relict fauna of Lough Neagh. It has been shown that near St. Bees this readvance penetrated a short distance inland, and Dr. Smith and Mr. Eastwood inform me that records of borings in the ground south of Egremont, together with an exposure near Rothersyke in the Ehen Valley, suggest that the ice drove inland across the course of the Ehen, for a distance of about four miles from the coast, and stood against ground to the north-east, well above the present level of Ennerdale Water. As local topography here is favourable for reproducing the conditions invoked by Professors Hogbom and Charlesworth either by way of the St. Bees or Ehen valleys, a similar suggestion is worthy of consideration.

This by no means exhausts the possibilities, for the detailed mapping of the Ennerdale area has shown that another oscillation of unknown magnitude occurred at the mouth of Ennerdale at an earlier stage in the retreat of the glaciers from Cumberland. Details of this oscillation cannot be given here, but will appear in the forthcoming Whitehaven Memoir.

It may be said that, as far as can be ascertained in the present state of our knowledge, Ennerdale appears to lie in a more favourable position for the introduction of *Limnocalanus* than do the other Cumbrian Lakes.

Yours, etc.,

28 Jermyn Street, S.W.1. S. E. HOLLINGWORTH.

RAILWAY ACCIDENTS AND THEIR CURE.

To the Editor of DISCOVERY.

SIR,

The subject of Lord Monkswell's article in your issue for this month is a legitimate one for a scientific periodical, were the article written with any approach to the scientific attitude of mind. But that attitude is not consistent with the advancement of sweeping assertions unsupported by evidence, nor with a disregard of the sense of proportion.

If British railways are as inert, and as impervious to improvement, as Lord Monkswell would have your readers believe, how comes it that a traffic of the density which our railways carry—a density which, in England and on main lines, is I believe not appreciably surpassed in any other country—is conveyed with a degree of safety, and at an *average* speed, unparalleled elsewhere ? Lord Monkswell's name is familiar to those interested in railway matters through his persistent efforts to bring about the acceleration of express passenger services. With this aim I, for one, am in cordial sympathy. But a good cause is not helped, but retarded, by the advocacy which can descend to the reckless methods of controversy displayed in Lord Monkswell's present article, the tone of which helps one to understand why his endeavours to quicken our expresses have been fruitless.

I do not propose to take up your space by a disproof of Lord Monkswell's rash statements. I will content myself with remarking that my own systematic observations of locomotive performance on British lines—recorded in detail over a distance totalling well over 100,000 miles—enable me emphatically to deny his accusations in regard to the recovery of lost time. Should the figures be of interest I shall be happy to furnish them. Scientifically, however, disproof of one unsupported statement, in an article which teems with them, suffices to destroy confidence in the rest.

35 Briardale Gardens, Your obedient Servant,
London, N.W.3. H. MYERS.

FROM CRYSTAL TO TELEVISION.

To the Editor of DISCOVERY.

SIR,

I am obliged to your reviewer of my book, "From Crystal to Television," for pointing out a misleading remark as to the relation of *gamma*-rays to the cathode, *alpha*- and *beta*-rays, in my introduction. The *gamma*-ray is, of course, unique as being an emanation from the other rays. At the same time I had in mind the very general analysis of the electron-world which arose from the discovery of the vacuum tube and the exploration of cathode rays which it led to. I can forgive myself the looseness in the introduction but not in the "name of reference" index, where I should have been more precise.

Yours truly,

3 Loudoun Road, VYVYAN RICHARDS.
St. John's Wood, N.W.8.

Tradition and Customs in Bakomy.

By J. E. Pryde-Hughes, F.R.A.I.

Following his recent articles on the "People of the Great Plains" the author here describes the exploits of the last highwaymen and some of the marriage customs in Bakomy, from information gained at first-hand.

WHEREVER one strikes the Danube one must journey on its broad bosom, or tramp along its historic banks. From Budapest, I turned my footsteps westwards along the river in a roundabout tramp to the Bakomy Forest, for centuries the royal hunting ground and the home of those highwaymen known as the Betyas.

The banks of the Danube are low hereabouts, but the current is strong enough, nevertheless, to turn the great wheels of the strange river mills—now passing rapidly away through pressure of the modern electric factories. These mills are really boathouses securely moored in the stream, the miller and his family living aboard. As the current forces the great wheel round so the corn is ground—a quaint survival fighting desperately against economic fact, but most certainly doomed. I continued up the river to Esztergom, the centre of Hungarian religious life and the supposed birthplace of St. Stephen, the first King of Hungary, who was crowned in 1001. It was St. Stephen who introduced Christianity amongst the Magyars, and from his time Hungary has stood as a bulwark against pagan attacks on Western Civilization; time and again she was forced to fight for existence against Mongol and Turkish hordes.

LAKE BALATON, HUNGARY.
A group of fishermen, in their heavy primitive craft, are resting after the day's toil.

Not many miles away on the same side of the river is Babolno, the famous Arab stud, and further west Pannonhalma, the foundational monastery of the Benedictines, who received a charter from St. Stephen which is still preserved and which I was privileged to see. From Pannonhalma the road to the forest led through Zircs, where the foundational monastery of the Cistercians stands, and then to Veszprem, where the bishop's palace overlooks the wide Bakomy from the top of a cliff. Stretched far and wide as the eye can see are ancient hunting grounds where, in days past, the gay monarchs of the land hunted all kinds of game. In the woods of the Bakomy one comes across caves, which tradition says run right down to the great lake Balaton and which were the chief hiding places of the Betyarok, those Claude Duvalian highwaymen, of whom it is said that they never robbed the poor, harmed women, or carried out their business other than courteously. Fortunately, or unfortunately, the Betyar died out about fifty years ago, and so I was unable to test by actual experience the truth of the stories told of them. But I have a shrewd suspicion that like our Sheppards and Dick Turpins, time has tended to give a romantic touch to what was probably a very sordid business.

The highwaymen of the Bakomy Forest flourished in the year following Hungary's liberty war of 1848. They were undoubtedly a queer kind of highwayman; though they all rode horses, the work was done by daylight and in a comparatively restricted area, while at the same time they made it their especial pride ever to behave gallantly towards their victims, whom they never mishandled. They were sometimes called the "poor boys," and, as they never harmed the poor (and indeed helped them) or robbed the peasantry, the countryfolk were on their side and frequently protected and hid them when the gendarmes

were on their tracks. Many tales are told of their wild life, and, as usual, when hunted they ever managed to elude their pursuers, or so the tales run; nevertheless, they were eventually exterminated, and I trod the Bakomy without fear of ghosts or imitators.

In the villages to this day songs are sung of the Betyarok, and one who told me some of the tales related how years ago an old lady acquaintance had described an actual experience with these picturesque robbers, who appeared at her house when the men were in the vineyards, and demanded three horses and two hundred florins. Very polite they were but firm, and when she handed them all her money they counted out the two hundred florins, which they pocketed, and returned her the rest. Then, begging her pardon for the inconvenience she had been put to, they raised their hats and a minute later she heard them galloping away. There must have been something extraordinary about the manners of these fellows, for "Betyar-honour" is a saying used to this day.

THE PENINSULA AT TIHANY.
A band of local peasants awakening to the renowned sixteen-fold echo which can be heard near the ancient monastery at Tihany.

Veszprem presented me with one of those little incidents which make tramping in strange places so attractive. The porter at the inn seemed strangely perturbed when I wrote "Angol," or British, after my name in the visitors' book. He was so obviously upset that I asked the reason. Then he told me that I was the first Briton he had ever seen in Veszprem, and he was overwhelmed with shame that he could not speak to me in his mother tongue, for his father was an English jockey from Lancashire who had settled in Hungary years before the war. I chided the poor fellow a bit and then he sold me a painting which had been left at the hotel in lieu of rent by an artist who had stayed there. And I think I have unconsciously made a bargain on the strength of the porter's sentimentality.

From Veszprem the road leads one on to Szekesfehevar, the old royal town of Hungary, where the tomb of St. Stephen was discovered. When the body was exposed it immediately crumbled to dust with the exception of the right hand which was miraculously preserved. The fact was a portent of great significance to the Hungarians, who regard the hand with great reverence. Once a year it is carried in solemn procession from the Palace overlooking the Danube, on the site where Arpad is said to have made camp over one thousand years ago, to St. Mathias Church in Buda, followed by tens of thousands of good Hungarians who believe that so long as the right hand of St. Stephen remains intact it will lead the nation wisely.

Never leaving the territory of the royal hunting grounds, my route led me to the shores of Lake Balaton, a large lake banked on its western shores by an interesting range of volcanic hills. It is forty-four miles long and from two to nine miles wide, and its total area is about 375 square miles. Locally it is known as the Hungarian sea. It is practically cut in two by the Tihany peninsula with its peaks of lime tufa; on the top of the most important of these is the delightful Benedictine monastery of Tihany. Here it was that the unfortunate Karl, last of the Hapsburgs, remained in safe keeping until the British Monitor "Glowworm" steamed up the Sio canal—a canal with the beauty of a wayward river—and into the great lake. At the little watering-place below Tihany, Karl stepped aboard "Glowworm" and was carried off to that exile which terminated with his death. The crypt of the monastery was built by King Endre I in 1052, sufficiently long ago for it to be of interest to such as delight in ancient things. The sixteen-fold echo which made Tihany a place of renown for the peasantry has unhappily suffered from the planting of trees, but it is still sufficiently attractive; often the visitor will be surprised by groups of gaily costumed country youngsters making unearthly noises that are repeated in dwindling volume through all the nooks and crannies of the peninsula, which juts out a mile into the lake.

In the south-western corner of the lake, where the curious basaltic columns of Mount Szent György (St. George) remind one of the Giant's Causeway, nestles tiny Tapolcza with its idyllic warm lake, while in the vineyard district, not so far away, is Badacsony, the home of a rather fiery, but really

good wine. Badacsony has a bathing place, and from the hills overlooking the village—it is scarcely more, like all places on Balaton—fine views of the lake and surrounding country and its numerous ruined castles can be obtained. The castles—and there seems to have been one clinging to every peak or mound with any pretensions at all—were all blown up after the Rakocsy insurrection, which may have been either a wise precaution or severe retribution for patriotism and love of freedom, according to how one looks at it, but was nevertheless unfortunate.

The lake is widest between Vilajos and Almadi, being about eight or nine miles across at this spot. There are no mysterious depths or fabulous whirlpools, though there are level changes of the water—not ebb and flow of the ocean, but a see-saw change which is also known on the Lake of Geneva. "The rumbling of Balaton" (Balaton *haborgasa*) is the chief phenomena—a sudden disturbance of the water without apparent cause, and which is sometimes dangerous. In the north the bathing is splendid; the water is here shallower than in the south, where depth and muddy bottom make it less attractive. In summer time the water is often 23° C., and at such favourable times sun baths are most enjoyable after a swim. Long stretches of sandy shore slope gently into the waters, and one can wade a long way before getting out of depth—so gradual is this slope that one is astonished at times to see herds of cattle standing in the waters a long way off the shore; troops of horses too, and strangest of all, herds of swine—long wire-haired animals. At Füred there are trout ponds, and the lake is stocked with fish which are sometimes caught by means of an ancestral wicker-work trap, the origin of which must be well back into primitive times. Of the fish a perch pike (the *fogas*) is the best for table, but there are also pike, carp and shad (the Balaton herring). Along the reedy banks millions of waterfowl make their homes, and at Little Balaton, in the south-west, large numbers of herons are to be seen.

To those who seek new and even more charming places for the summer vacance, Balaton supplies the want; in winter, too, the lake freezes over and good skating is general, but there is no organized winter sport. But my interest did not lie so much in this direction. The people appealed more to me, with their charming hospitality and their beautiful old-fashioned costumes and strange customs. The Hungarians, though a well educated and advanced peasantry, cling tenaciously to their old customs, and the chief of these are connected with courtship and marriage. For marriage is a serious matter in this land where women, and particularly mothers, are regarded with honour.

FISHERMEN ON LAKE BALATON.
Many of the various devices still used by these fishermen are very primitive; a wicker-work trap is often to be seen.

Courting is not a furtive sport of country lanes and secluded spots, but a very regularized proceeding. In some parts the boy, who has set eyes on a girl who takes his fancy, places three apples at the door of her house overnight, and if next morning they are cut in half, and half taken away, he knows he may press his suit; so, too, in other places the love-sick lad will hang his great-coat — the beautifully embroidered *szur* —on the loggia outside his lady's house, and next morning he goes round furtively to see if it has been touched. If taken inside, or turned inside out, he may hope; but if untouched, he must walk disconsolately away. With betrothal, rings are not given, but the boy receives from his sweetheart a handkerchief which he wears on his sleeve, much as the knights of old wore their lady's favours. He in turn, in certain districts, presents his sweetheart with a sugar loaf which she places in her window that passers-by may know she is engaged.

The marriage festival is a very gay affair. In this part of the country, amongst the clan known as the Bessenyos, the bridegroom in his gay robes, with flowing *gatya* or divided skirts as worn by the peasantry all over Hungary, is brought by the crown men to the house of the bride, who in flowing terms is demanded of the father. They speak of the bride in flowery language, referring to her beauty and charms extravagantly. The bridegroom leads his horse draped in a white cloth and carries the bride's banner, woven and embroidered by her own hands, her first gift to him. But previously the crown men,

or best men, have been busy; they have to visit the bridesmaids and receive their crowns of laurels; earlier still they have gone round with personal invitations to the festival, the first to be invited being the bride, despite the fact that it is her parents who provide the feast. Then on the day, the procession of the whole village to the church is led by the chief crown man who carries a flask of wine from which he will drink the health of the wedded couple. The bridesmaids carry a small tray with glasses, from which, while still at the altar, the newly-married couple will drink to their eternal friendship. On the way back the crown man bears a live cock which he will flutter occasionally in the air. This is to characterize the fine and brave groom, then it will be killed and placed before the groom at the festive table. The feast over, dancing commences, for at every opportunity the Hungarian peasant dances.

The customs differ slightly with the various clans, but always marriage is a serious matter, and especially perhaps for the boy, who, until he is married, will be considered as a boy and so treated by his comrades and elders. Though usually somewhat taciturn, at the wedding festivals and such like the lively spirit of the Hungarians comes to the surface; melancholy or gay, however, they are people of moods—a courteous and delightfully hospitable folk, whose history, country, life and customs are of the deepest interest.

Among the Stars: A Monthly Commentary.

By A. C. D. Crommelin, D.Sc., F.R.A.S.

THE FACE OF THE SKY FOR JANUARY.

Most of the planets are now on view at a convenient hour of the night. Uranus is on the meridian not long after sunset and should be looked for as early as possible. Neptune is near Regulus, and is high enough for observation at 10 p.m. Charts of the stars near these two planets are contained in the new B.A.A. Handbook for 1929. Mars is still well placed, though further away than last month; on the other hand it reaches a high altitude earlier in the night. Jupiter is still observable. The eclipses of the satellites now occur a good way from the disc and there is a favourable eclipse of III on 1st January from 8.30 to 10.20 p.m.

Mercury and Venus are both evening stars; Mercury may be detected low in the south-west in the twilight about 21st January. Venus is in the same direction but higher up. It appears gibbous in the telescope; it will increase in diameter during the month, but the illuminated portion of the disc will diminish. It reaches greatest elongation, 47 degrees from the sun, on 7th February, when it will be just half illuminated. The moon is near Venus on 14th January, which will help to locate the planet in the telescope before it is dark. There are no occultations of bright stars this month, but there are two on 16th January at 6.34 and 8.58 p.m. respectively, which would be visible with small telescopes.

Comet Discovery.

The first cometary discovery for many months was made on 19th November by Mr. Forbes, an amateur astronomer at Cape Town. I have deduced the following orbit, but the observations used are too near each other in time to give a strictly accurate result. Perihelion passage 7th November at 1 a.m., Arc from node to perihelion 198° 32′, Node 248° 59′, inclination 28° 39′, perihelion distance 0.7472. These elements resemble so closely those of comets seen in February, 1818, and November, 1873, that I have very little doubt they are all the same comet, returning after intervals either of fifty-five years or of some fraction of this period. If fifty-five years is right, the comet travels to 28½ units from the sun, or very nearly to the orbit of Neptune, so that it may be looked on as belonging to the same family of comets as the famous one of Halley.

Eos, or the Wider Aspects of Cosmogony. By Sir J. H. Jeans, F.R.S. (Kegan Paul. 2s. 6d.).

This little book, consisting of eighty-eight small pages, and seven plates giving photographic reproductions of nebulae, is an exposition, in delightfully simple and attractive language, of the recent advances of knowledge as regards the size of the universe and its probable course of development in the past and the future. The enormous size of the nebulae is vividly brought out by the statement that any of the plates in the book would have to be magnified to cover all Asia before a body the size of the earth would be visible upon them.

The author is not one of those who think that the processes going on in the heavenly bodies can be looked on as continuing indefinitely either in the past or the future. He finds clear evidence of a great act of creation, which can be roughly dated as some eight millions of millions of years ago. Ever since that time the matter in the stars has been converting itself into radiant energy, at a rate that is very rapid for young stars, but that gets steadily slower as they grow old; he sees no probability of the reverse transformation, of radiant energy back to matter, taking place. The end may thus be more distant in time than the beginning; but ultimately all the matter of the stars (except perhaps of those that have turned into "White Dwarfs") will have turned into radiation. The author quotes the lines "The sleep eternal, in an eternal night" as describing the ultimate state; but he seems to have forgotten that he has already invoked creative power to explain the beginning of things, and that the same power remains active, though the manner of its action cannot be brought into mathematical discussion.

The tremendous mass of the sun is brought home by the statement that it loses a million million tons of matter every three days, and yet could go on shining at its present rate for fifteen millions of millions of years before it was all gone. There is perhaps a slight tendency in the book to exalt unduly the recent advances in knowledge. Even in old Greece many philosophers made surprising anticipations of modern results; and Sir William Herschel's views on the nebulae as being other universes only differed from those of Dr. Hubble by being on a slightly smaller scale.

Book Reviews.

Sir Isaac Newton. A collection of papers from the American Scientific Societies. (Balliere, Tindall & Cox. *22s. 6d.*).

This is one of the most important and certainly one of the most interesting books that we have seen about the man who is generally regarded as the greatest scientific genius the world has known.

The bicentenary of Newton's death fell in 1927, and it is fitting that there should have been a great revival of interest in his life and work. In England a large concourse of the most eminent men representative of all branches of science met together in Grantham, Lincs., to pay homage to his memory. The Pierpont Morgan Library in New York possesses Newtonian manuscripts of great interest which have been annotated and deciphered by Professor David Eugene Smith, the President of the History of Science Society, who offered the results of his work to the English *Mathematical Gazette* in the following graceful terms :— "It is entirely proper that all Newtoniana should be published in England first, in case this can be done." Much of this work was accordingly reproduced in an excellent memorial volume edited by W. J. Greenstreet for the Mathematical Society and published by Bell in 1927.

It is a matter of the greatest satisfaction and a significant indication of the close kinship between England and America that a similar meeting was held in New York on the 26th and 27th November, 1927, under the auspices of the principal American scientific societies. Each session was presided over by a world-famous American professor, and papers were read by various specialists on the influence of Sir Isaac Newton's work in their own branch of science. The present volume is the result of the American meeting. It is a collection of the papers read before the assembly, and the care with which each contribution has been written is ample evidence of the love and pride inspired in our American cousins by the genius of our common scientific ancestor, Sir Isaac Newton.

It will probably come as a surprise to many to discover that Newton's activities covered such a wide field. His work in astronomy is generally well known. To students of science his researches in optics and mathematics are fundamental ; yet even they perhaps do not appreciate the far-reaching influence he exerted on the philosophical opinions of his day, and the subsequent development of religious thought. It is a very curious thing that so little is known of Newton's work as Warden and afterwards Master of the Mint. There is very little doubt, however, that nowhere could have been found a more suitable man in every respect to superintend the recoinage, and to put an end to the malpractices that had sullied the fair fame of English integrity.

The paper contributed by Frederick E. Brasch of the Library of Congress, Washington, is of very great interest. It concerns John Winthrop (1714-1779) of Harvard University, who was the first true Newtonian disciple in America—Professor of Mathematics and Natural Philosophy at Harvard, at the age of twenty-four, he at once taught science on strict Newtonian principles. Mr. Brasch's sketch of his life and work is full of charm, and conveys in no uncertain manner a familiar sense of the long and virile traditions that inspire the American universities to-day. There is a beautiful portrait of John Winthrop sitting by a telescope and having his arm on a book which is said to be Newton's "Principia."

All students of science should be familiar with every detail concerning Sir Isaac Newton's life that they can lay their hands upon, for they will find no greater stimulus in their work. This volume should form part of every scientific library. In addition to this specialized value, it may be recommended to the general reader with complete confidence as a book of absorbing historical and current scientific interest which demands no technical knowledge as a preliminary to its enjoyment.

V. E. PULLIN.

Report of the Fuel Research Board for the period ended 31st March, 1928, with Report of the Director of Fuel Research. (H.M. Stationery Office. *1s. 3d.*).

It may be helpful to a just appreciation of this important report to view it in the light of what may be termed its "time context." It deals with the work done in the period immediately following the disastrous coal stoppage of 1926, which proved a serious handicap to the activities of the Fuel Research Station. The period has been one of unprecedented depression and unemployment in the coal mining industry.

The return issued by the Mines Department shows that in every quarter from 1st January, 1927, to the end of June, 1928, there has been a loss. The deficit, which represents the difference between the net costs and the proceeds of commercial disposal, has varied from 9d. to 1s. 5d. per ton of coal, the latter figure being for the quarter ending in June of this year. There has also been a constant decline in the number of men employed. These facts have caused public attention to be focussed on this most urgent of industrial problems. In consequence, there is a new eagerness in the study of any means which will enable the country to recover and increase the economic advantages to be derived from the exploitation of what has long been and what remains the most important raw material we possess.

Chief among the remedial measures is the intensive pursuit of research on fuel, a field in which all countries are engaged, and in which this country has played and is playing a distinguished part. For us more particularly, fuel research is intimately linked up with national prosperity and even safety. There is no doubt still scope for more intelligent and sustained co-operation between the scientists, the colliery owners, the industrialists of all kinds consuming power in some form, and the industrialists who are making fuel—whether it be gas or coke. It is, however, clear that co-operation is to-day at work and that its development and maintenance are directly helped by the activities of the Fuel Research Board.

It is interesting to compare the contents table of the report under review with the agendas of the Carbonization Conference held at Birmingham in February last, of the World Power Conference held recently in London, and of the International Conference on Bituminous Coal held in Pittsburgh in November last. Such a comparison reveals a substantial agreement as to the essential lines along which investigations should proceed.

First comes the survey of national coal resources. The report shows that the detailed picture is nearing completion. A laboratory has been equipped in the Durham and Northumberland area and work will be begun in the South Wales area before the end of the year. Exhaustive examinations of important seams are being carried out, and a systematic study made of the physical and chemical properties of coals and their suitability either alone, or blended, for various purposes. This work is of first importance and ought in time to make it impossible for collieries not to be able to give recent and accurate information as to the composition of coal in the seams they are working.

It will also help to the classification and to the most profitable disposal of various coals according to their particular values.

Attention has also been paid to the sampling and analysis, and more particularly to the standardization of the methods employed. This standardization, so desirable if the comparison of results obtained by different workers on the same material is to have any meaning, presents difficulties. As the report states, "If uniformity is to be obtained, some analysts will have to change their methods for others which are not necessarily intrinsically better." The Board has carried out experiments to determine the most efficient method of sampling and the best size of samples, bearing in mind differing local conditions. Sampling from the flowing stream during the loading or unloading of cargoes appears to give satisfactory and repeatable results for the ash content. As the Chairman of the Board says, "No matter how perfect the methods of analysis, the results are of little value if the sample on which they are used is not representative." A Sectional Committee of the British Engineering Standards Association has been appointed to deal with analysis and sampling, with a view to establishing British Standard methods. The main difficulty here is to reconcile the desirable with the really practicable.

It would be of the greatest service to fuel technologists if a standard method of expressing the calorific value of fuels could be established and used. At present different weight and volume units are used in different countries, and calculations are necessary to establish comparisons. Further, two values are in use, known as "gross" and "net" calorific values, depending on whether the heat of condensation of the water vapour in the combustion product is or is not available as a source of heat. The point is a technical one of great importance in the interpretation of results or in the giving of guarantees. It is stated that the practice of only using net calorific values for buying and selling fuel is becoming general in Germany.

No subject is so frequently discussed to-day in connexion with fuel than that of low temperature carbonization. This potentially very important method of treating coal has suffered from the degree and the kind of publicity it has received. The Fuel Research Board is the more to be commended for the low-toned and measured expression of its views on the subject. The report states that slow but steady progress has been made towards the accumulation of data necessary for determining to what extent and under what conditions, low temperature carbonization of coal will be a commercial success. The process developed at the Fuel Research Station is to be tried out on a large scale at the Richmond works of the Gas Light & Coke Company. At the same time the Board is keeping in touch with other processes, and has carried out tests on the Crozier and the Maclaurin plants.

The tenor of the report under this head is in accord with the view held by many, that low temperature carbonization is desirable from a national point of view to produce smokeless fuel and not inconsiderable amounts of oil, but that as yet no process has passed with flying colours through a stringent economic test. One will look forward with interest to any work bearing on the use of the fuel produced for blending purposes and for industrial heating.

It can only be mentioned in passing that, in connexion with the gas industry, work has been continued on vertical and horizontal gas retorts, on water gas and its purification and on coke. It is suggested that modifications in gasworks practice may produce a more free burning coke suitable for use in open grates. In connexion with metallurgical coke, it is very desirable that large scale tests should be made and the effect of blending of coals investigated. Among other subjects reported on are pulverized fuel and the spirit obtained from low temperature carbonization. Such spirit is reported as having a high "anti-knock" value.

To many, the most interesting part of the report is that dealing with the hydrogenation of coal. The work is not directed towards examining the immediate commercial possibilities, as this work is in the hands of Imperial Chemical Industries Ltd., but rather to the study of the chemical reactions involved. The very suggestive observation is recorded that in the case of every coal tested, including anthracite, hydrogen is absorbed under suitable conditions of temperature and pressure, leading to a definite increase in its caking power and also to an increased tar yield. The publication of the detailed results will be keenly awaited as they bear directly on the nature of coal and foreshadow new methods for its industrial processing.

A close study of this report leaves one with the feeling that of the public money spent on research, no portion is more likely to prove a sound investment than that allocated to the Fuel Research Board.

A. T. DE MOUILPIED.

The Art of the Cave Dwellers. A Study of the Earliest Artistic Activities of Man. By G. BALDWIN BROWN, M.A., LL.D., F.B.A. (John Murray. 18s.).

Professor Baldwin Brown's book is an expansion of a series of lectures delivered on the Robert Munro Foundation in Anthropology and Prehistoric Archaeology in the University of Edinburgh. It would have given intense gratification both in matter and in treatment to the founder of the Lecture. It deals with a subject in which he was intensely interested and on which he himself lectured with authority; and it justifies the faith that was in him that the drawings, engravings and sculptures of the palaeolithic caves were to be ranked among the great artistic achievements of man. In estimating the merits of the art of palaeolithic man, there is always a danger that the enthusiasm of the archaeologist may outrun his knowledge of aesthetic principles, while the judgment of the art-critic may be affected by the limitations of his archaeological knowledge. Professor Baldwin Brown is an expert in both archaeology and aesthetics. His book is therefore no mere recapitulation of material that is already familiar. His profound knowledge of the examples of the art of palaeolithic man is here reviewed from the point of view of the critic.

The principle of the freedom of art—art for art's sake in the words of a once popular phrase—in its application to palaeolithic art has been eclipsed by the doctrine that the paintings and engravings of the French caves were entirely magical in intention. Recently, however, it has shown some signs of revival, and in France M. Luquet has argued ably that art existed as art before it could become magical. Professor Brown holds something of a middle position, which he expresses in the formula that "every artistic activity and every form of artistic production is preceded by similar activities and similar forms of production that are not artistic." Artistic feeling, he holds, shows itself as a regulating, and not as a motor agency. He is thus able to take up the position that whatever may be the stimulus, magical or utilitarian, the desire of the artist for self-expression finds vent while in the act of the producing. With this as his point of view, the author examines the data of the archaeologist, not confining himself to the paintings and engravings of palaeolithic man, though these necessarily occupy first place, but taking into account also the fine flint working of the implements of

St. Acheul and Solutré, the personal ornaments, and the dance as we know it, and inductively finding the aesthetic test in that method of arrangement in relation which, for lack of a more expressive term, may be called "composition."

Professor Baldwin Brown offers an attractive suggestion for the beginnings of representative art which leads him to point out that palaeolithic art is essentially a hunter's art and incidentally to ridicule the idea of some "imaginative" writers that the artist was the weakling and dreamer of the tribe.

A word must be said for the illustrations. A book of this type is unintelligible without some illustration. Yet books on aesthetics rarely have adequate provision. Here there is hardly a point made in the text which is not illustrated on the same page by the photograph of an actual specimen. Over half the photographs are by the author himself, and much of the material will be new to the majority of readers.

E. N. FALLAIZE.

The Ramblings of a Bird-Lover. By CHARLES E. RAVEN, D.D., Canon of Liverpool Cathedral. (Martin Hopkinson. 10*s.* 6*d.*).

The title of a book is not invariably a precise criterion of its contents; it is so, however, in regard to Dr. Raven's volume, "The Ramblings of a Bird-Lover." From cover to cover we are presented with delightful first-hand field-studies; from cover to cover we follow the story of a passionate lover of birds. And what charming exposition! Not only concerning the birds themselves—some of which are very commonplace and abundant—but also the expeditions made to reach them. Though Dr. Raven may soar to the heights of Olympus in his descriptive powers; though he can embellish his cultured pen still further by well placed metaphor and simile, he never gets out of bounds; he is never unduly grandiose. His homely, chatty remarks, bubbling here and there with humour, point to a versatile mentality, and to a man gifted with fine sociable qualities. Sociable, yes; for we follow not only the author, but also his family, and at times others, participating in the joys of the bird-rambles. His journal throughout bears a personal touch which goes home to the heart of his readers.

Dr. Raven's passionate love for birds manifests itself in his equally passionate love for securing permanent pictures. He is an indefatigable photographer. The sixty-seven half-tones which illustrate his book, cover a very wide field of study. His love of the "Kindergarten" is dominant, and comes much into evidence in his photographs secured during his expeditions to Holland's famous bird-sanctuaries. He provides many photographs of nestlings.

The rambles are in the main confined to the British Isles; nevertheless, they are so markedly diversified that the reader is afforded ample opportunity of gaining an insight into the habits of many different types of birds. Birds of the crags and mountain precipices, the home of the buzzard and the raven; birds of the beetling sea-cliffs, puffins, guillemots, razorbills, kittiwakes, and others; birds of the marsh, mere, and loch, coots grebes, and the larger divers; birds of the open sand-flats and shingle, hosts of sandpipers, gulls, terns, and others, too numerous to mention. Taken as a whole, these rambles furnish a delightful and thorough survey. To follow in their wake is a tonic to the ardent field-naturalist: an inspiration to young and old alike.

C. J. PATTEN.

Gentlemen prefer Aeroplanes. By E. F. SPANNER. (E. F. Spanner, 9 Billiter Square, E.C.3. 35*s.*).

This volume is a sequel to "This Airship Business" by the same author, who feels that the Air Ministry experts have not only failed to meet, but have evaded, the challenging arguments included in his first volume and voiced at the Royal Aeronautical Society and other meetings. He makes it quite clear that he has no financial or political interest in the matter, but that he considers it to be in the public interest for the expenditure of the taxpayers' money to be stopped until a financially disinterested committee has pronounced judgment on the designs of R 100 and R 101, here discussed in detail.

The first section of the book outlines for the non-technical readers the meaning of aeronautical terms, and, with the aid of many diagrams, gives a brief scientific explanation of the problems connected with "superheating," steady axial flight, stability and "pressure-height." In the light of the experience of the R 34 in its two Transatlantic flights he draws a dismal picture of the plight of a future passenger, who has paid a substantial sum for the voyage, due to the disturbing and quite unavoidable consequences of fog, rain, storms, snow, frost, and the quick variations of temperature and weather; these unpleasant conditions being additional to the discomforts of the normal flying inclination of several degrees and the "bumping" experienced in the temperature "dunts"—of sudden occurrence and uncalculable effect.

It is not, however, solely on the score of discomfort that Mr. Spanner bases his attacks on the future usefulness of large airships for passenger traffic. It is against the specific design of the two airships R 100 and R 101 that he directs his attack in great detail in the second and third sections of the book. We are assured that "the enterprise into which we have been rushed by Sir Samuel Hoare and Lord Thomson is destined to involve loss of life and of British Air Prestige, because the designs of R 100 and R 101 are technically unsound. . . . The right time to investigate this material and to thrash out criticisms is now, and not after the disaster."

The evidence Mr. Spanner adduces seems to be borne out by the experience of past experiments. Yet, although the prospect before heavier-than-air machines seems more full of promise for the future, we cannot fully endorse the view that no further useful advance can be made in airship construction.

The Intimate Papers of Colonel House. Arranged by CHARLES SEYMOUR, Professor of History at Yale University. Volumes III and IV. (Ernest Benn. 42*s.* the set.)

Few problems in recent history have been the subject of more debate than the American relation to Europe. With Woodrow Wilson at the helm, the United States raised the hopes of the European peoples exhausted by war and then appeared to abandon the Council of Nations which he did so much to bring into being. Apart, therefore, from the value of any new records of the war period, these "Intimate Papers"—written by the man who came to be known as the President's "silent partner"—come as near to the initial root of this problem as any clue with which the historian is likely to be provided.

The earlier volumes, published in 1926, concluded with America's entry into the war, and told the story of a friendship that was to have such a remarkable sequel—the combination of politician and unofficial adviser that later broke down every

precedent in diplomatic procedure. From the moment when in 1912 he refused a post in Wilson's first Cabinet, for the next seven years House came to influence many important decisions in American politics, having from the first a deep sense of American responsibility and interest in Europe.

It was natural, therefore, that when President Wilson declared war on Germany, he should look to Colonel House for advice on American relations with the Allies—at this point the new volumes take up the story. The President selected him as chief of the organization for preparing the American case at the Peace Conference, appointed him head of the American War Mission to Europe for the co-ordination of military and industrial efforts, asked him to draft a constitution for a league of nations, and again sent him to Europe as American representative on the Supreme War Council when it arranged the armistice with Germany. At the Peace Conference, where House was Commissioner Plenipotentiary, the President constantly used him to conduct the most delicate negotiations, and during Wilson's absence from Paris and illness, selected him to take his place on the Supreme Council.

That such unusual privileges were allowed to one who held no diplomatic position was truly extraordinary. A freer relationship than hitherto exists between the statesmen of Europe, but our formalities increase the difficulties of the American, who has in any case first to penetrate our traditional reserve. Deeper reasons must be sought for the separation that followed the Peace Conference, but this factor has undoubtedly contributed to misunderstanding. Several letters addressed to House remark with obvious relief that American diplomatic representatives are spared the elaborate uniforms of older nations; and this dislike of ceremony finds its deepest expression in the record which House made of the signing of the Peace Treaty at Versailles. Chasseurs in gorgeous uniforms lined both sides of the entrance to the magnificent Hall of Mirrors, and after the signing the cannons began to boom. "It was not unlike what was done in olden times," wrote House, "when the conqueror dragged the conquered at his chariot wheels. To my mind it is out of keeping with the new era which we profess an ardent desire to promote. I wish it could have been more simple and that there might have been an element of chivalry, which was wholly lacking. The affair was elaborately staged and made as humiliating to the enemy as it could be."

The reader may be disappointed that Colonel House himself is unable to explain his final estrangement from Wilson, which remains "a tragic mystery," but this is perhaps in keeping with the nature of the papers. Was it that the President, in the hour of his political defeat, came to resent even more than his own broken spirit, the man to whom he had delegated so much authority?

Modern Conceptions of Electricity. By CHARLES R. GIBSON. (Seeley Service & Co. 12*s*. 6*d*.).

There can be no doubt that Dr. Gibson has included all the modern uses of electricity in this book, and he has explained the general ideas in a very readable manner. There are one or two minor slips in the text, such as on p. 128. Surely the *main* supplies of raw material for the extraction of radium element are not Joachimstal and Cornwall. The plate facing p. 200 was produced in *Discovery* some months ago to illustrate an article on the recent work of Dr. W. D. Coolidge on high velocity cathode rays. The title of the illustration in the present book is incorrect. It is not a Coolidge X-ray tube, but a cathode ray tube of Dr. Coolidge's design. Similarly the experiments with the rabbit's ear were conducted with cathode rays and not as it is stated with X-rays.

Chapter XIV on thermionic valves will interest many readers, and Dr. Gibson illustrates his clear explanation of valves and their working with some excellent little sketches. Such difficult matters as Relativity, the Quantum Theory and Crystal Structure all receive attention. The book is well illustrated with plates of general interest and many clear explanatory diagrams. It may be recommended as an interesting popular resumé of modern electrical science.

V. E. P.

Three Boy Scouts in Africa: On Safari with Martin Johnson. By R. D. DOUGLAS, D. R. MARTIN, and D. L. OLIVER. (Putnam. 6*s*.).

The photographic achievements of Mr. and Mrs. Martin Johnson during their many safaris on the African continent have been appreciated on both sides of the Atlantic through the medium of the cinema. It is this which makes of so much interest the joint account of the three American boy scouts who, through the generosity of three friends of the Scout Movement, were enabled to accompany Mr. and Mrs. Johnson on safari in East Africa for five weeks during the last southern winter.

Few white boys ever have the opportunity of seeing the larger wild beasts at any closer quarters than the modern zoos afford, yet these three have had the opportunities of seeing the wonders of the jungle under the guidance of those whose interest is the observation, and not the destruction, of wild animals.

The Discovery of the Rare Gases. By MORRIS W. TRAVERS, D.Sc., F.R.S. (Edward Arnold. 15*s*.).

The author of this volume, who worked with Sir William Ramsay for the ten years during which most of the work on the discovery of the Rare Gases was undertaken, has performed his task with credit. The account he gives us is a scientific work—the result of his original intention to annotate and summarize the contents of Sir William Ramsay's scientific papers, which had been entrusted to him by his relatives—yet at the same time it is of very general interest to any who have sufficient knowledge of general chemical principles to appreciate the sustained and painstaking effort necessary for such an advance of knowledge. Writing of researches in which he was actually engaged, the author lays stress on the continual friendly relations, unhampered by controversy, which Lord Rayleigh and Sir William Ramsay always enjoyed; and also on the gracious way in which the latter dealt with his many critics.

In the author's own words, "I offer no apology for retaining personal touches, which I might not have introduced into a work primarily intended for publication. However, the greater part of the story was written with one figure always in mind; and there are many who will understand my wish that the human element should remain, and that this should be no mere dry record of scientific investigation." His wish is justified; the book is a useful reminder of the greatness both of the man and his share in the achievement of this discovery.

The facsimile reproductions from Ramsay's notebooks are excellent; but the year in which the various experiments took place is not always made clear—a few errors in the printed dates adding greatly to the confusion of the reader.

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